PUBLIC REVIEW
DRAFT October 1978

Carbon Monoxide And Total Suspended Particulate Air Quality Control Programs

San Francisco Bay Area
~~NON~~-ATTAINMENT PLAN

Prepared By

ABAG
ASSOCIATION OF BAY AREA GOVERNMENTS

BAY AREA AIR QUALITY MANAGEMENT DISTRICT

MTC Metropolitan Transportation Commission

with assistance from

CALIFORNIA AIR RESOURCES BOARD

CALIFORNIA DEPARTMENT OF TRANSPORTATION

CARBON MONOXIDE AND PARTICULATES

AIR QUALITY CONTROL STRATEGIES

REVIEW SCHEDULE

Public Discussions

November 8	1:30 p.m	ABAG Regional Planning Committee
November 16	7:30 p.m.	ABAG Executive Board Hotel Claremont Berkeley
December 13	1:30 p.m.	ABAG Regional Planning Committee Hotel Claremont Berkeley

Public Hearing

December 21	7:30 p.m.	ABAG Executive Board acting for the General Assembly Hotel Claremont Berkeley

Plan Approval

January 13	9:30 a.m.	General Assembly California Maritime Academy Vallejo

Executive Summary

Carbon Monoxide and Total Suspended Particulates

Air Quality Control Programs

SAN FRANCISCO BAY AREA AIR QUALITY PROBLEMS

The San Francisco Bay Area is designated under the 1977 Clean Air Act as a region where three national ambient air quality standards are not attained. Under the 1977 Clean Air Act, the Association of Bay Area Governments was designated by the California Air Resources Board to prepare, in cooperation with the Bay Area Air Quality Management District and the Metropolitan Transportation Commission, a non-attainment plan for meeting Federal standards for oxidant, carbon monoxide (CO) and total suspended particulates (TSP). This plan is to be included in a revised State Implementation Plan and submitted to the U.S. Environmental Protection Agency.

ABAG's General Assembly adopted an air quality maintenance plan in June 1978. That plan was designed to reduce hydrocarbon emissions, provide for attainment of the Federal oxidant standard by 1985-87 and maintain the standard thereafter. The AQMP is currently being reviewed by the Air Resources Board, and will form the basis for the oxidant control strategies of the Bay Area's non-attainment plan.

PURPOSE OF THE CONTROL STRATEGIES

This summary covers the CO and TSP portions of the non-attainment plan, which is required under Section 175 of the Clean Air Act Amendments of 1977. The CO and TSP portions of the non-attainment plan set forth actions necessary in the Bay Area to meet the Clean Air Act requirements. In the case of carbon monoxide, the plan describes the nature of CO problems in the Bay Area and outlines the technical difficulties in preparing a regional plan for a pollutant where emissions vary widely throughout the region. The plan shows how several actions to control hydrocarbon emissions (already adopted by the ABAG General Assembly in June) will provide reasonable further progress in meeting the CO standard.

In the case of total suspended particulates, the plan describes the recent history of violations of various Federal and State particulate standards. Most recent monitoring data of the Bay Area Air Quality Management District shows the Federal primary standard is now being attained. The plan outlines a program for attaining other Federal and State particulate standards as part of the air quality continuing planning process.

THE NATURE OF CARBON MONOXIDE PROBLEMS

Carbon monoxide levels in urban communities vary widely with time and location. CO is emitted directly in the exhaust of motor vehicles, which is the principal source of CO emissions. Once in the atmosphere, meteorological factors such as winds and convective processes tend, under normal conditions,

to rapidly disperse the pollutant. As a result, the typical distribution of ambient CO closely follows in time and location the distribution of motor vehicle traffic. High CO concentrations can therefore be expected in places where traffic is congested. In addition, traffic congestion involves vehicles which are operating at low speeds or idling, and which are accelerating and decelerating rather than moving smoothly. CO emission rates are substantially higher under such conditions, thus magnifying ambient CO concentrations. Research previously conducted has established that ambient CO levels are highest along busy city streets or highways, and drop rapidly with distance from the road. This "microscale" variation of ambient CO levels is in sharp contrast with photochemical oxidants, which tend to cover large regional areas.

Carbon monoxide is considered a public health hazard. Typical symptoms of CO exposure are headache, nausea, decreased visual acuity, increased response time, poor time interval distinction and reduced maximal work rates. Those segments of the population most susceptible to the adverse effects associated with atmospheric CO include individuals with anemia, cardiovascular disease, chronic pulmonary disease and the developing fetus.

The Federal ambient air quality standards for CO have been set at 35 parts per million (ppm) for one-hour, and 9 ppm for eight-hours. A CO problem may thus be defined as a violation of the one-hour or eight-hour Federal ambient CO standards. According to EPA guidelines, the National Ambient Air Quality Standards are applicable to that portion of the atmosphere, external to buildings, to which the general public has access. The key phrase is "to which the general public has access". Thus, regardless of the likelihood that any single individual would remain in a given location for one hour or eight hours to receive a CO exposure greater than that allowed by the standards, the standards must be met in such a location as long as it is accessible to the general public. Table 1 summarizes some common examples of both reasonable and unreasonable locations for application of the CO standards as identified in EPA guidelines.

Table 1. Applicability of the CO Standards

Reasonable locations	Unreasonable locations
- All sidewalks where the general public has access on a continuous basis.	- Median strips on roadways
- A vacant lot in which a facility is planned and in whose vicinity the general public would have access	- Locations within the right-of-way on limited access highways (e.g., freeways).
- Portions of a parking lot to which pedestrians have access continuously.	- Within intersections or on crosswalks at intersections.
- Property lines of all residences, hospitals, rest homes, schools, playgrounds, and the entrances and air intakes to all other buildings.	- Tunnel approaches - Within tollbooths

Source: Environmental Protection Agency

This interpretation of the standards is apparently necessary because it is not possible to establish that no one would remain at a publicly accessible location for more than one or eight hours. Therefore, to ensure the protection of public health, the standards must be met at all such locations. If the standard were interpreted to apply to CO exposures for "typical" individuals traversing the same locations but not remaining for the requisite one or eight hour periods, peak CO levels greater than the ambient standards could be tolerated.

The Federal one-hour CO standard has never been exceeded at BAAQMD urban air monitoring stations. The Federal eight-hour standard (9 ppm) has been exceeded on numerous occasions and at several locations, as summarized in Table 2.

CARBON MONOXIDE CONTROL STRATEGIES

The actions identified in this plan element presume continued enforcement of State and Federal new vehicle emission standards. The actions include:

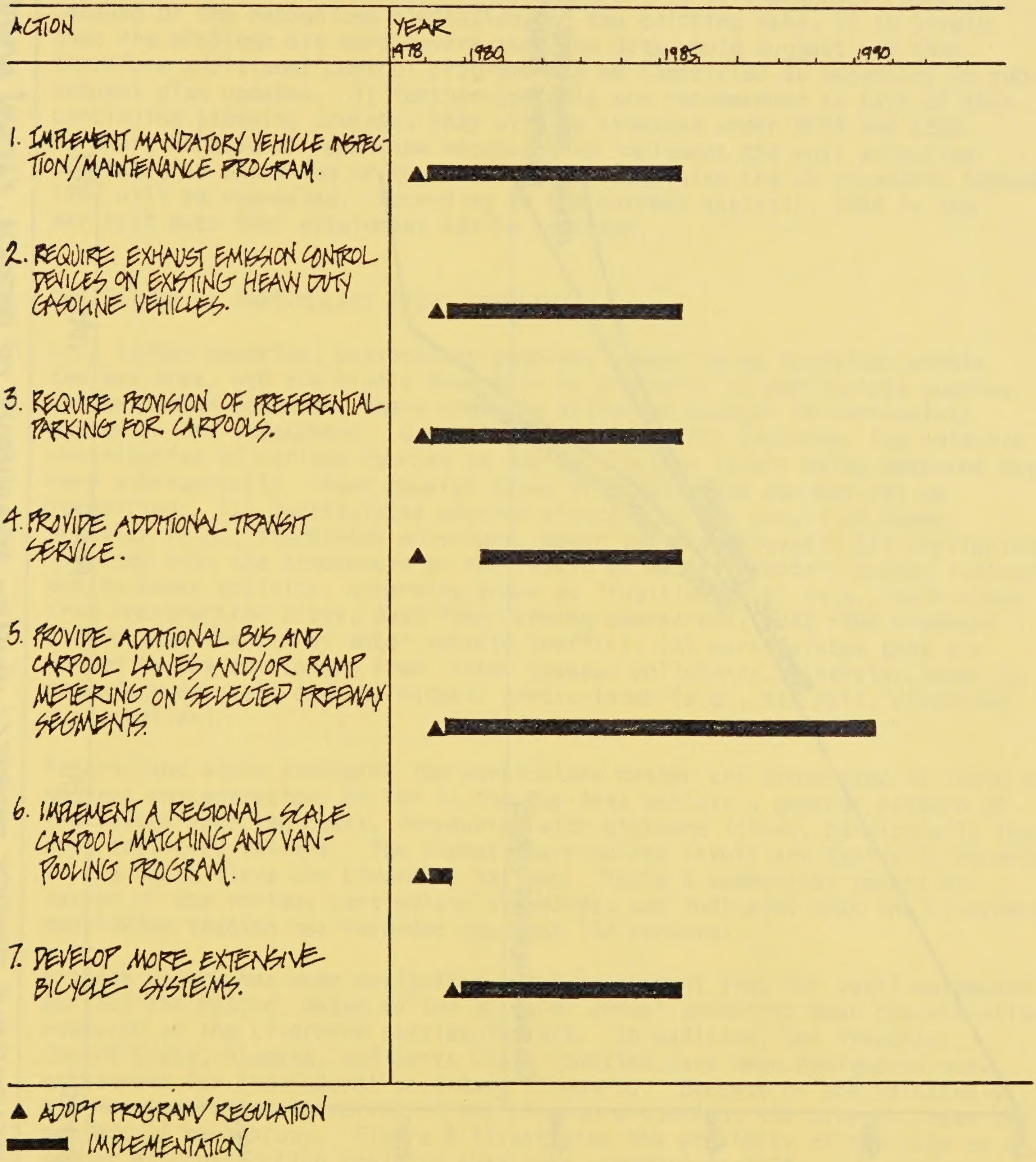
- implementation of a mandatory annual vehicle inspection and maintenance program
- implementation of a heavy duty gasoline truck exhaust catalyst retrofit program
- preferential parking for carpools
- transit service improvements
- additional ramp metering and high occupancy vehicle lanes on selected freeway segments
- implementation of expanded regional carpool and vanpool matching program
- implementation of a comprehensive system of bicycle paths and storage facilities
- collection of additional data to more accurately characterize CO problems at selected locations
- continuing analysis, evaluation, and control strategy development as new information is collected

All of the actions (see Figure 1) identified for carbon monoxide controls were adopted as part of the Bay Area's hydrocarbon control strategy in the AQMP. They were subjected to detailed assessment required under the National Environmental Policy Act (NEPA) and an environmental impact report was prepared under the California Environmental Quality Act (CEQA) for the Environmental Management Plan (including the AQMP). No additional CEQA assessment is done for the carbon monoxide control strategies since no additional control programs are recommended at this time. Implementation of the recommended controls will provide reasonable further progress toward attaining the CO standard as required by the Clean Air Acts (see Figure 2).

Table 2. CARBON MONOXIDE PROBLEMS: 1975 - 1977

Location	1975 Days over 8 hr. std.	1975 High 8 hr. avg.	1976 Days over 8 hr. std.	1976 High 8 hr. avg.	1977 Days over 8 hr. std.	1977 High 8 hr. avg.
San Francisco	3	12.9	4	11.0	0	-
Oakland	4	10.9	7	10.5	0	-
San Jose	18	15.9	61	20.2	32	14.4
Sunnyvale	9	10.6	14	12.8	1	10.6
Vallejo	12	12.6	40	18.0	13	14.2

FIGURE 1
SCHEDULE FOR IMPLEMENTATION OF THE CARBON MONOXIDE PLAN



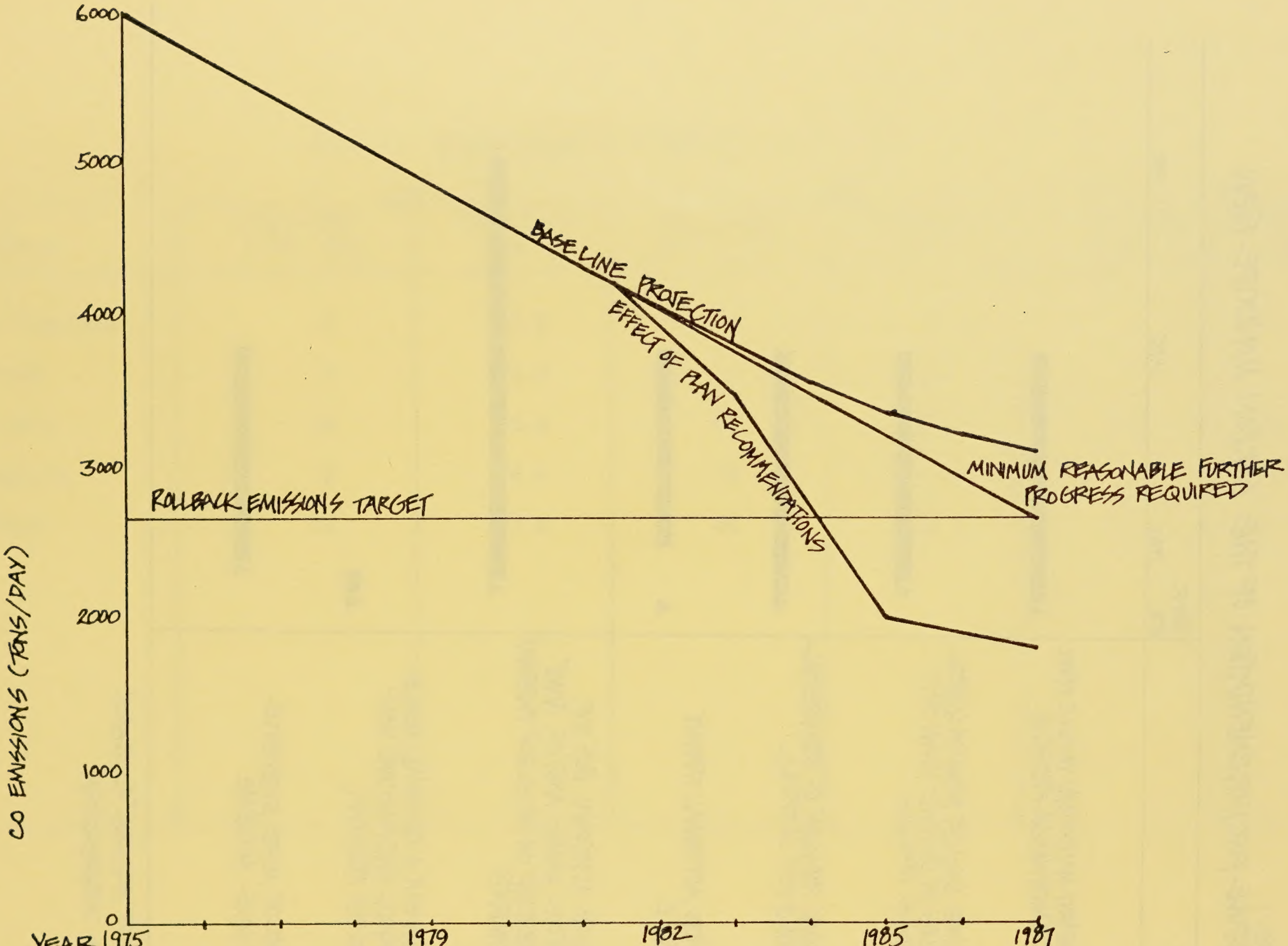


FIGURE 2

PROJECTED REASONABLE FURTHER PROGRESS TOWARD ATTAINMENT OF FEDERAL CARBON MONOXIDE STANDARDS. (BASED ON LINEAR ROLLBACK AND IMPLEMENTATION OF ALL RECOMMENDED CONTROL PROGRAMS.)

A crucial aspect of this plan element is the further characterization of CO problems in the region and continuing plan development as needed (see Figure 3). The existing data on carbon monoxide do not provide a complete picture of the problem. The recommended actions will, according to existing data, result in attainment and maintenance of the CO standards. However, because of the recognized limitations of the existing data, it is likely that the problems are more severe than the data would suggest and that therefore additional control programs may be identified as necessary in subsequent plan updates. If further controls are recommended as part of this continuing planning process, they will be assessed under NEPA and CEQA. Further, because of lead time necessary to implement the most effective programs, an extension of the deadline for attaining the CO standards beyond 1982 will be requested. According to the current analysis, 1984 is the earliest date that attainment can be expected.

THE NATURE OF PARTICULATE (TSP) PROBLEMS

Like carbon monoxide, particulate problems appear to be localized within the Bay Area, and are highly dependent on proximity to particulate sources. Unlike carbon monoxide, there are many different sources of particulate matter in the atmosphere. Depending on the specific location, the relative contribution of various sources to the particulate levels being measured may vary substantially. Four general types of particulate sources can be identified: (1) particulates emitted directly as the result of human activity (e.g., industrial emissions, motor vehicle exhaust); (2) particulates injected into the atmosphere as the result of natural factors and/or indirectly due to human activity, otherwise known as "fugitive dust" (e.g., dust blown from construction sites, dust from farming operations, dust from roadways kicked into the air by motor vehicle traffic); (3) particulates that are formed in the atmosphere from other gaseous pollutants, otherwise known as secondary aerosol; and (4) natural particulates (e.g., sea salt, windblown dust, pollen).

Federal and State standards for particulate matter are summarized in Table 3. Ambient concentrations of TSP in the Bay Area exhibit a general pattern of low values near the coast, increasing with distance inland, particularly into dry, sheltered valleys. The highest particulate levels are typically recorded in the Santa Clara and Livermore Valleys. Table 4 summarizes recent excesses of the various particulate standards, and indicates that the Livermore monitoring station has recorded the most TSP excesses.

Alameda County has been designated a non-attainment area for total suspended particulate matter, based on the 80 $\mu g/m^3$ annual geometric mean concentration measured at the Livermore station in 1975. In addition, San Francisco, Contra Costa, Alameda, and Santa Clara Counties have been designated non-attainment for the Federal secondary standards. Because of the relatively high concentrations observed at the Livermore station, the site has been the subject of much study. Figure 4 illustrates the proximity of the site to a number of construction projects that were underway in 1975.

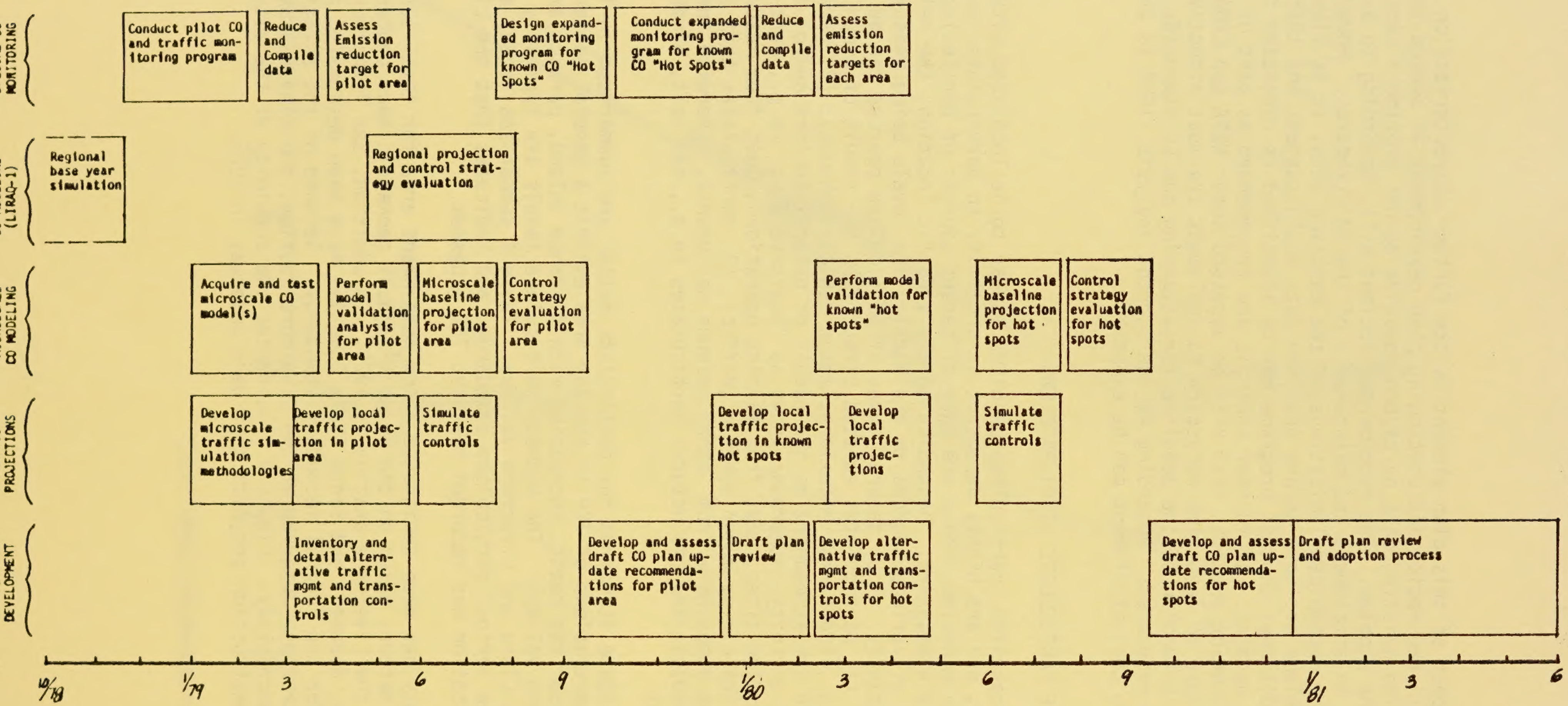


Figure 3 TENTATIVE SCHEDULE FOR FUTURE WORK ON CARBON MONOXIDE PLAN UPDATE

Table 3. Ambient Air Quality Standards for Suspended Particulates

Averaging Time	California Std.[1]	National Standards[2]	
		primary[3]	secondary[4]
24-hour[5]	100 μg/m³	260 μg/m³	150 μg/m³
1-year[6]	60 μg/m³	75 μg/m³	60 μg/m³

(The high volume sampler[7] is the accepted test method.)

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[1]California standards should not be equalled or exceeded at any time.

[2]National standards, other than annual averages, are not to be exceeded more than once per year.

[3]National primary standards are the levels of air quality necessary, with an adequate margin of safety, to protect the public health. Each state must attain the primary standards no later than three years after the implementation plan is approved by the EPA.

[4]National secondary standards are the levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant. Each state must attain the secondary standards within a "reasonable time" after the implementation plan is approved by the EPA.

[5]The 24-hour average is obtained by weighing the total particulate catch on a filter from a continuous 24-hour sampling period.

[6]The annual geometric mean (AGM) is the product of all the 24-hour readings, divided by the number of readings; or equivalently, the antilog of the (arithmetic) average logarithm of the individual readings.

[7]EPA method specified in Federal Register, Volume 36, Number 84, Friday, April 30, 1971, p 81, or 40 CFR 50.6, 50.7 and Appendix B.

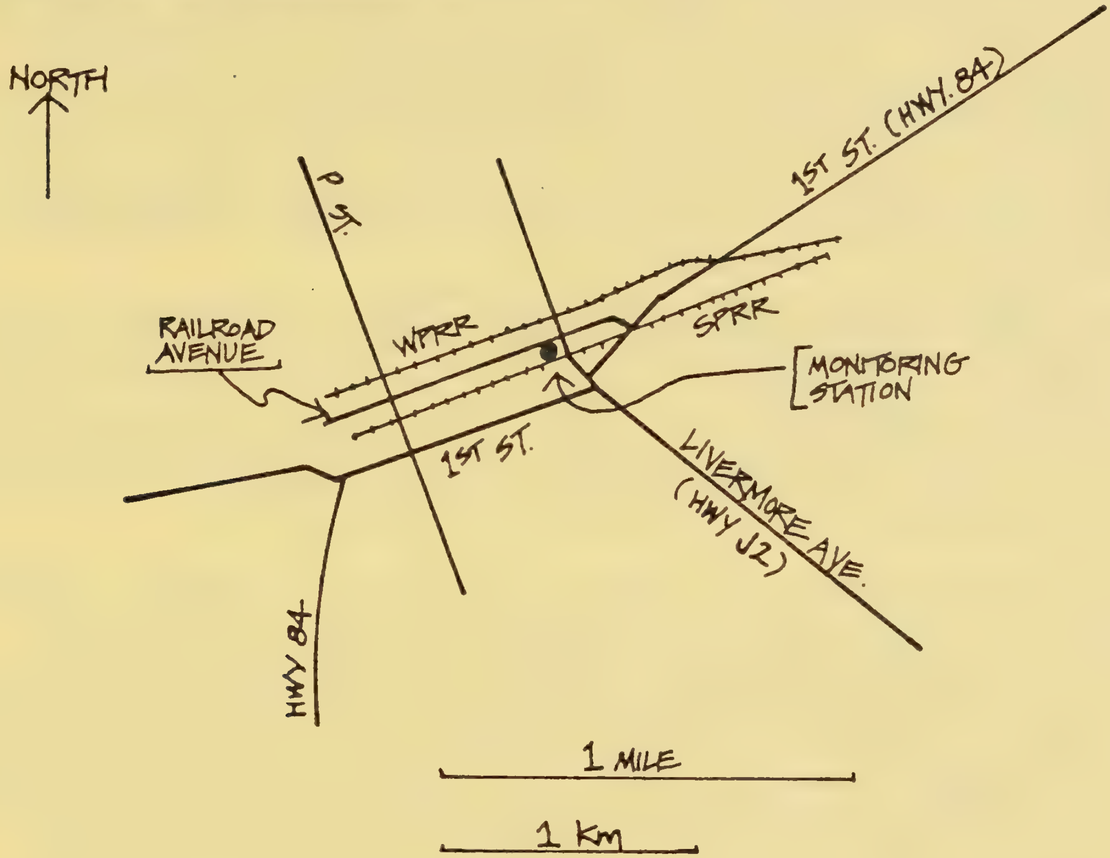
Table 4. Summary of TSP Monitoring Data in the Bay Area, 1972 - 1978

Averaging Time	Standard (μg/m³)		- Year - 1972	1973	1974	1975	1976	1977	1978**
24 hr	100	number of stations with ≥ 1 excesses	6	15	16	15+	19+	15+	7+
	state	% of sampling days over std., highest station	17(L)*	23(P)	23(L)	23(L)	41(L)	19(L)	16(L)
24 hr	150	number of stations with >1 excess	1	7	10	12	18	8	4
	national secondary	% of sampling days over std., highest station	1(L)	3(L)	5(L)	13(L)	11(L)	2(L)	1(B)
24 hr	260	number of stations with >1 excess	0	0	2	0	0	0	0
	national primary	% of sampling days over std., highest station	--	--	1(v)	--	2(c)	--	--
annual (AGM)	60	number of stations over standard	1	3	1	2	12	3	1
	state std. and national sec. "guideline"	highest station value (station)	67(L)	66(L)	71(L)	80(L)	85(L)	68(L)	62(L)
annual (AGM)	75	number of station over standard	0	0	0	1	1	0	0
	national primary	highest station value (station)	--	--	--	80(L)	85(L)	--	--
Total*** number of stations in network			15	17	18	19	19	20	18

*Station identifier: (L) = Livermore, (c) = Concord, (v) = Vallejo.
**Partial year data, January through June, 1978.
***Total number of sampling sites, including BAAPCD stations and NASN sites, with sampling at one site for entire calendar year.

FIGURE 4

LIVERMORE MONITORING SITE



CONSTRUCTION PROJECTS IN THE VICINITY OF THE STATION

NO	DATES	DESCRIPTION
1	?	RAILROAD RELOCATION - MOVE SP TRACKS FROM SP RIGHT-OF-WAY TO WP ROADBED.
2.	6/74 - 3/76	LIVERMORE AVENUE UNDERPASS. HIGHWAY GOING UNDER RAILROAD.
3.	6/74 - 2/76	P STREET UNDERPASS, ROAD UNDER RR
4.	74 - 75	RELOCATION OF HIGHWAY 84, EARTH MOVING ALONG SP RIGHT OF WAY.

RECOMMENDED APPROACH FOR FUTURE PLANNING

Based on the recent monitoring record, it is expected that the Livermore station AGM will be below 75 $\mu g/m^3$ for the forseeable future. The three conditions which contributed to high TSP in 1975 and 1976 (construction, drought and extreme restrictive meteorology) are not expected to recur, especially simultaneously. The general composition of the Livermore TSP is known, with 35% soil-like particles as the largest fraction and 24% soot-organics as the second largest. Since neither of these is amenable to modeling at this time, we rely on the developing monitoring record to demonstrate attainment by 1978. The 1977 AGM was 68 by BAAQMD calculation and the 1978 AGM is 63 through July 1978.

Substantial reductions in the hydrocarbon inventory are expected as the oxidant plan is implemented, and the construction near the Livermore station has been completed. Thus both fugitive dust and organic components should be substantially reduced, though the reductions may not be quantified except through the monitoring record. After two clean years, 1977 and 1978, Alameda County may be redesignated by the ARB or EPA as an attainment area with respect to the national primary particulate standards.

The attainment of secondary standards in four counties presents a more difficult problem, where the solution will depend on control of fugitive dust. With winter rural inland background values of about 30 $\mu g/m^3$ with excursions to 100 $\mu g/m^3$, it is clear that the estimation and control of fugitive dust will be a demanding and critical task. It is clear that a useful calculation of fugitive emissions must depend on careful analysis of the existing data, and possible the publication of new research. Even with agreement on emission factors, the fugitive emissions calculations will require collection and analysis of new kinds of data in the Bay Area: crop acreage, unpaved roads and areas, soil moisture, soil particle sizing, precip./evaporation indices, etc. This exercise may require several person-years of work and up to one calendar year to accomplish.

The following tasks are identified and recommended for completion as part of the continuing planning process for air quality:

- Evaluate potential effectiveness of stricter enforcement of existing regulations to control fugitive dust from human activities; opacity limits and public nuisance laws could be invoked for dust control at construction and demolition (or any other) sites.
- Allow fugitive dust reductions for trade-offs in new source review requirements.
- Request State and/or Federal funding for the source identification program proposed in AQMP/Tech Memo 24 for size segregated sampling and elemental/microscopic analysis of particulate samples.
- Collect data and prepare a fugitive dust emission inventory for the Bay Area on a county-by-county basis. Model individual stations in non-attainment areas.
- Monitor change in national policy from a total suspended particulate standard to a fine particle standard--inhalable or respirable fraction.

- Evaluate the potential effectiveness of particulate control alternatives, including Best Available Control Technology for particulate matter emission control on new and existing sources, particulate traps for gasoline and diesel engine emissions control.

- Design and set up experimental fugitive dust control programs near monitors if the local inventory analysis predicts benefits.

- Evaluate the experimental programs for air quality benefits and implementation costs.

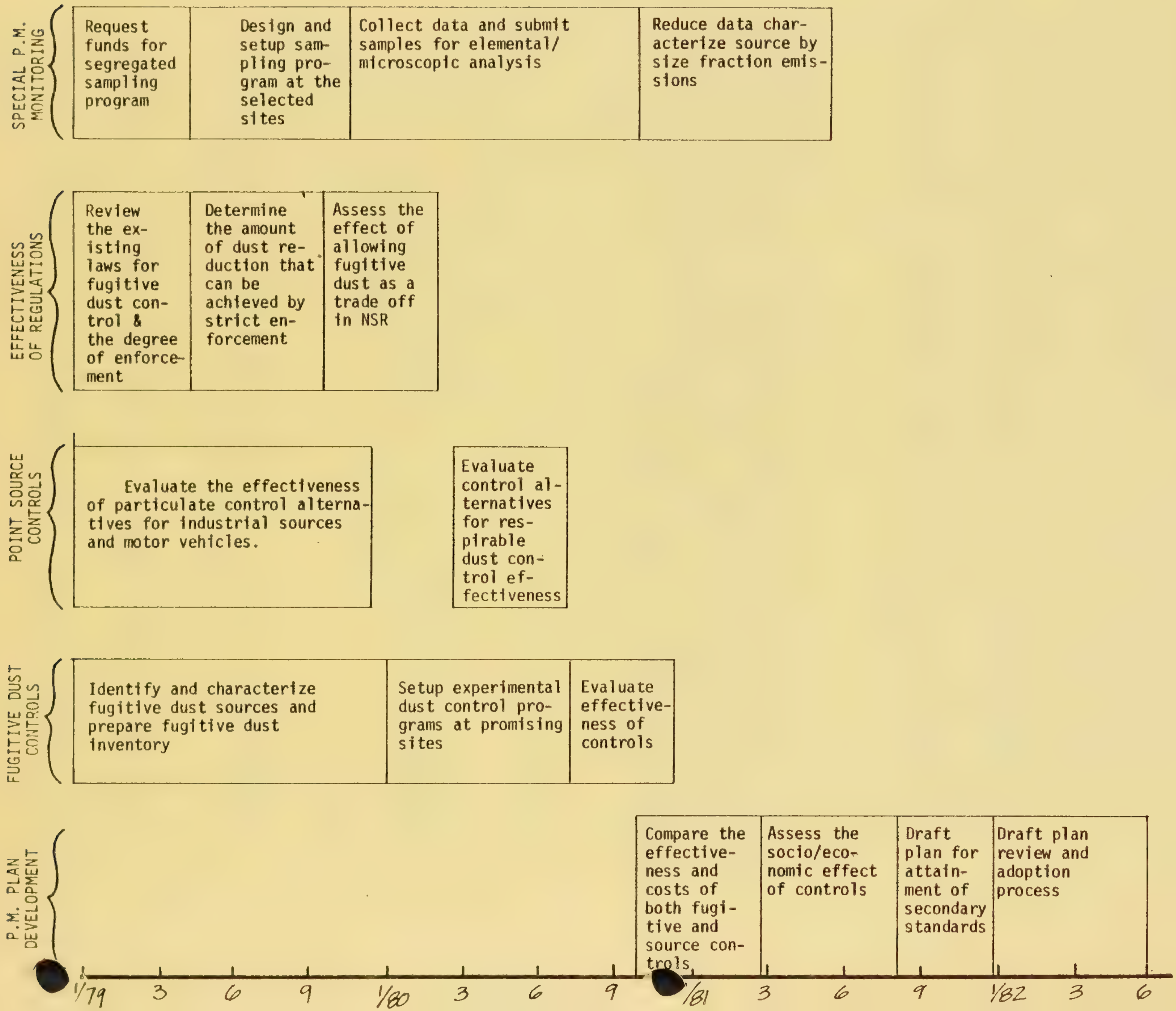
- Formulate plans for attainment of secondary (and state) standards based on results above, and assess the social, economic and other environmental effects of any additional control programs recommended.

A tentative schedule for completion of these tasks is illustrated in Figure 5 assuming appropriate funding (e.g., nonattainment area planning funds) is available by January 1979.

PUBLIC REVIEW

The plan elements will be reviewed by the ABAG Regional Planning Committee on November 8 and December 13. Public comment on the actions will be received at those meetings. The ABAG Executive Board will hold a public discussion on the plan at its November 16 meeting, and a formal public hearing on the plan will be held by the Executive Board, acting for the General Assembly, on December 21. The General Assembly is scheduled to adopt the plan elements at its January 13 meeting.

Figure -5 TENTATIVE SCHEDULE FOR WORK ON PARTICULATE MATTER PLAN UPDATE



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Part 1

Carbon Monoxide

Section-A
INTRODUCTION

The San Francisco Bay Area is designated under the 1977 Clean Air Act as a region where three national air pollutant standards are not attained. Under the 1977 Clean Air Act, the Association of Bay Area Governments was designated by the California Air Resources Board to prepare (in cooperation with the Bay Area Air Quality Management District and the Metropolitan Transportation Commission) a non-attainment plan for meeting Federal standards for oxidant, carbon monoxide and total suspended particulates. This plan is to be included in revised State Implementation Plan and submitted to the U.S. Environmental Protection Agency.

ABAG's General Assembly adopted an air quality maintenance plan in June 1978 (Reference 1). That plan was designed to reduce hydrocarbon emissions, provide for attainment of the Federal oxidant standard by 1985-87 and maintain meeting the standard thereafter. The AQMP is currently being reviewed by the Air Resources Board, and will form the basis for the oxidant control strategies of the Bay Area's non-attainment plan.

The purpose of this plan element is to set forth the actions necessary to attain and maintain Federal ambient air quality standards for carbon monoxide in the San Francisco Bay Region. It has been prepared as part of the continuing planning process established by the Bay Area Environmental Management Plan to satisfy the non-attainment plan requirements of the 1977 Clean Air Act Amendments.

The actions identified in this plan element presume continued enforcement of State and Federal new vehicle emission standards. The actions include:

- implementation of a mandatory annual vehicle inspection and maintenance program
- implementation of a heavy duty gasoline truck exhaust catalyst retrofit program
- preferential parking for carpools
- transit service improvements
- additional ramp metering and high occupancy vehicle lanes on selected freeway segments
- implementation of expanded regional carpool and vanpool matching program
- implementation of a comprehensive system of bicycle paths and storage facilities
- collection of additional data to more accurately characterize CO problems at selected locations

- continuing analysis, evaluation, and control strategy development as new information is collected

All of the actions identified for carbon monoxide controls were adopted as part of the Bay Area's hydrocarbon control strategy in the AQMP (Reference 1). They were subjected to detailed assessment required under the National Environmental Policy Act (NEPA) and an environmental impact report was prepared under the California Environmental Quality Act (CEQA) for the Environmental Management Plan (including the AQMP). No additional CEQA assessment is done for the carbon monoxide control strategies since no additional control programs are recommended at this time.

A crucial aspect of this plan element is the further characterization of CO problems in the region and continuing plan development as needed. As is discussed in subsequent sections, the existing data on carbon monoxide do not provide a complete picture of the problem. The recommended actions will, according to existing data, result in attainment and maintenance of the CO standards. However, because of the recognized limitations of the existing data, it is likely that the problems are more severe than the data would suggest and that therefore additional control programs may be identified as necessary in subsequent plan updates. If further controls are recommended as part of this continuing planning process, they will be assessed under NEPA and CEQA. Further, because of lead time necessary to implement the most effective programs, an extension of the deadline for attaining the CO standards beyond 1982 will be requested. According to the current analysis, 1984 is the earliest date that attainment can be expected.

THE NATURE OF CARBON MONOXIDE PROBLEMS

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Carbon monoxide is considered a public health hazard. Typical symptoms of CO exposure are headache, nausea, decreased visual acuity, increased

response time, poor time interval distinction and reduced maximal work rates. Those segments of the population most susceptible to the adverse effects associated with atmospheric CO include individuals with anemia, cardiovascular disease, chronic pulmonary disease, and the developing fetus (See Reference 3).

The Federal ambient air quality standards for CO have been set at 35 parts per million (ppm) for one-hour, and 9 ppm for eight-hours. A CO problem may thus be defined as a violation of the 1-hour or 8-hour Federal ambient CO standards. According to EPA guidelines (References 5 and 6), the National Ambient Air Quality Standards are applicable to that portion of the atmosphere, external to buildings, to which the general public has access. The key phrase is "to which the general public has access". Thus, regardless of the likelihood that any single individual would remain in a given location for one hour or eight hours to receive a CO exposure greater than that allowed by the standards, the standards must be met in such a location as long as it is accessible to the general public. Table 1 summarizes some common examples of both reasonable and unreasonable locations for application of the CO standards as identified in EPA guidelines (See Reference 5).

This interpretation of the standards is apparently necessary because it is not possible to establish that no one would remain at a publicly accessible location for more than one or eight hours. Therefore, to ensure the protection of public health, the standards must be met at all such locations. If the standard were interpreted to apply to CO exposures for "typical" individuals traversing the same locations but not remaining for the requisite one or eight hour periods, peak CO levels greater than the ambient standards could be tolerated (See Reference 7).

PUBLIC REVIEW

The CO plan element will be reviewed by the ABAG Regional Planning Committee on November 8 and December 13. Public comment on the actions will be received at those meetings. The ABAG Executive Board will hold a public discussion on the plan at its November 16 meeting, and a formal public hearing on the plan will be held by the Executive Board, acting for the General Assembly, on December 21. The General Assembly is scheduled to adopt carbon monoxide control strategies at its January 13 meeting.

Table 1. Applicability of the CO Standards

Reasonable locations	Unreasonable locations
- All sidewalks where the general public has access on a continuous basis.	- Median strips on roadways
- A vacant lot in which a facility is planned and in whose vicinity the general public would have access	- Locations within the right-of-way on limited access highways (e.g., freeways).
- Portions of a parking lot to which pedestrians have access continuously.	- Within intersections or on crosswalks at intersections.
- Property lines of all residences, hospitals, rest homes, schools, playgrounds, and the entrances and air intakes to all other buildings.	- Tunnel approaches
	- Within tollbooths

Source: EPA, Reference 5

Section - B

CO PROBLEMS IN THE SAN FRANCISCO BAY AREA

According to data collected by the Bay Area Air Quality Management District at its continuous urban monitoring stations, the Federal one-hour CO standard has not been exceeded in the current decade.* However, the Federal 8-hour average standard of 9 ppm has been frequently exceeded in some areas. Figure 1 illustrates the number of days in 1975 which were detected by the monitoring network to exceed the 8-hour standard. The major excess area is the Santa Clara Valley, centered on San Jose and extending to Sunnyvale. There is a small secondary maximum over Vallejo, and isolated urban-center cases at San Francisco, Oakland, and San Rafael. Table 2 summarizes the excesses of the CO standards which have been recorded in recent years. The highest 8-hour average CO level recorded in recent years was 20.2 ppm, which occurred in San Jose on November 5-6, 1976.

Over 80 percent of the violations occur in November, December, and January. On a daily basis more than 90 percent of these 8-hour excesses occur between 4 p.m. and 2 a.m. The timing of the 8-hour excesses can be explained by the winter season formation of surface-based radiation inversions which correspond in time period to the evening traffic maximum. Once initiated, a sustained buildup of high CO levels occurs and remains undispersed for many hours.

THE CO SAMPLING NETWORK

The locations of continuous CO sampling stations in the San Francisco Bay Area are also illustrated in Figure 1. There are 16 stations within the region where CO is monitored, and the sites have generally been selected to monitor representative community exposure levels for multiple pollutants (i.e., what was previously referred to as the urban background concentration). Relative to CO monitoring networks in other major metropolitan areas, the Bay Area network is among the most extensive. However, considering the significant localized variations in CO levels, it is difficult to determine whether the sites are "representative." For example, there is only one monitoring station in San Jose, a city of roughly 50 square miles in area, with a population of approximately a half million. A special survey was conducted in 1970-71 to compare CO levels measured at the San Jose station, which at the time was located about 1½ miles south of the downtown area of the city, with CO levels measured at other points across the city (see Reference 2). The results of the survey indicated that the station

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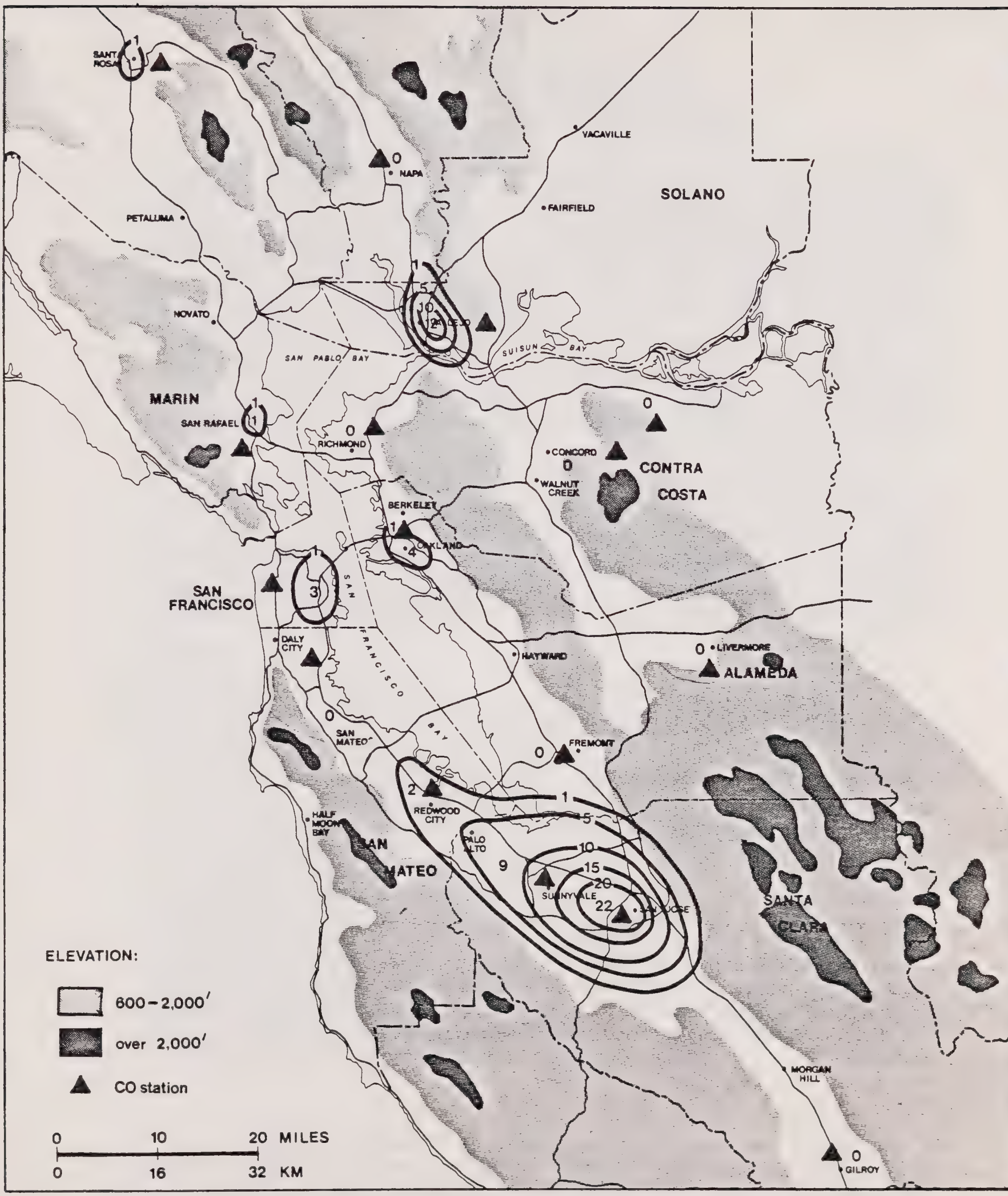
* Because of the very localized nature of CO concentrations, it is likely that the one-hour standard has been exceeded in other locations. For example, a recent BAAQMD monitoring program conducted at San Francisco International Airport recorded one-hour average CO levels as high as 86 ppm.



1975 Annual Number of Days with Carbon Monoxide Exceeding Federal Standard (9 parts per million for 8 hours).

Figure 1

Table 2. CARBON MONOXIDE PROBLEMS: 1975 - 1977

Location	1975 Days over 8 hr. std.	1975 High 8 hr. avg.	1976 Days over 8 hr. std.	1976 High 8 hr. avg.	1977 Days over 8 hr. std.	1977 High 8 hr. avg.
San Francisco	3	12.9	4	11.0	0	-
Oakland	4	10.9	7	10.5	0	-
San Jose	18	15.9	61	20.2	32	14.4
Sunnyvale	9	10.6	14	12.8	1	10.6
Vallejo	12	12.6	40	18.0	13	14.2

underestimated the CO concentrations experienced by pedestrians on downtown First Street in San Jose and overestimated concentrations at other locations not near heavily travelled streets. In particular, eight-hour average concentrations measured adjacent to heavily travelled downtown streets were as much as three times the values recorded concurrently at the air monitoring station. Thus, it is evident that Federal ambient air quality standards can easily be exceeded at many locations without being exceeded at the monitoring stations.

The U.S. Environmental Protection Agency has prepared guidelines for siting CO monitors which recognize the wide variation in CO levels at different locations (see Reference 4). These guidelines are summarized in Table 3. Four site types are distinguished:

- Street Canyon - This site type is usually within the central business district (CBD) in an area of congested stop and go traffic, with relatively uniform and tall buildings (five stories or higher) lining both sides of the street. This type of site is further divided into peak and average sites.

- Neighborhood - This type of site is representative of those areas of uniform land use (residential and commercial, etc.) away from street canyon effects, in which a captive population (i.e., the worker, resident or invalid) is exposed. This is a longer term exposure compared to the commuter and shopper in the street canyon. This type of site is also divided into two types, peak and average.

- Corridor - This type of site is intended to bridge the gap between the street canyon site and the neighborhood site. It is intended to describe those areas in which a heavily travelled arterial or freeway impinges on a neighborhood.

- Background - This type of site is intended to represent regional or rural background CO levels.

With respect to the site classifications, the Bay Area monitoring stations may be characterized as neighborhood stations. The Vallejo station is strongly suspected to be influenced by interstate 80, and thus could be considered a corridor station. Nowhere in the Bay Area is a peak street canyon situation currently being monitored. Therefore, the representation of current CO problems provided by existing data is incomplete.

The problem with these guidelines is that with the diversity of conditions and the sheer size of the Bay Area, the Air Quality Management District

Table 3. CO MONITOR PROBE EXPOSURE CRITERIA

Site Type	Height Above Ground	Expected Concentration Gradient with Height (1-hr. Average)	Separation of Monitor from Influencing Sources	General Remarks
Street Canyon				Central business district high density slow moving traffic. Dense multiple story buildings lining both sides of street. > 10 m from intersection.
Peak Conc.	3 ± ½ m	= .5 ppm/m	Mid-sidewalk or 2 m from side of building. On leeward side of street.	
Average Conc.	3 ± ½ m	= .3 ppm/m	Mid-sidewalk or 2 m from side of building.	
Neighborhood			Setback — VPD 3.5 km — 100,000 1.5 km — 50,000 200 m — 10,000 100 m — 5,000 35 m — 1,000 25 m — any	Commercial or residential neighborhood. This separation criteria limits the effect of these streets to = 1 ppm.
Peak Conc.	3 ± ½ m	5%/m		
Average Conc.	3 ± ½ m	5%/m		
Corridor	3 ± ½ m	< .3 ppm/m > . 5%/m	Dependent on traffic volume, road configuration and set-back distance of commercial or residential activity.	Stop and go or limited access traffic > 50,000 VPD or greatest in area.
Background	3 to 10 m	.2%/m	5 to 6 km; > 3000 VPH max 400 m; > 100 VPD	35 km downwind in least frequent wind direction from city, limit effects to .2 ppm.

SOURCE: EPA, Reference 4

does not have the financial resources to fully implement them. A smaller city with a well-defined city center and uniform meteorological conditions could probably characterize its CO problems with a half-dozen CO stations. In the Bay Area, the City of San Jose alone should probably have a half-dozen stations.

TRAFFIC CONDITIONS IN THE VICINITY OF KNOWN PROBLEM AREAS

The principal sources of data that characterize CO problems in the region are the continuous monitoring stations. Since the CO levels recorded are strongly influenced by traffic conditions in the immediate vicinity of each monitor, such conditions are described for each location at which excesses of the CO standard have been recorded.

SAN JOSE

The San Jose monitor is located in the downtown area (See Figure 2). It is in a one-story commercial building, adjacent to a small parking lot. The area around the San Jose central business district (CBD) contains a number of governmental offices and a variety of commerical establishments. Figure 3 illustrates the volumes of traffic near the San Jose monitor. The one-way couplets (1st - 4th Streets) carry significant volumes. Santa Clara Street, which is a block from the monitor, carries the heaviest traffic in the east-west direction. This street is also apparently a popular gathering spot for younger drivers on weekend evenings. The peak traffic volumes occur in the afternoon and evening hours. On Santa Clara, the peak hour has about 8% of the daily traffic, while the north-south streets generally carry about 11% of their traffic in the peak hour.

The San Jose Redevelopment Agency is anticipating several major new developments in the downtown area in the very near future, including a major hotel, several high-rise office towers and a major retail shopping center. Much of this will occur just west of San Jose State University. A number of changes in the downtown street system are anticipated. These include:

- Closure of Second Street between San Fernando and San Carlos Streets;

- Conversion of First and Second Streets to two-way traffic with one moving lane in each direction subsequent to the closure of Second Street;

Figure 2 - Location of Air Quality Monitor in San Jose

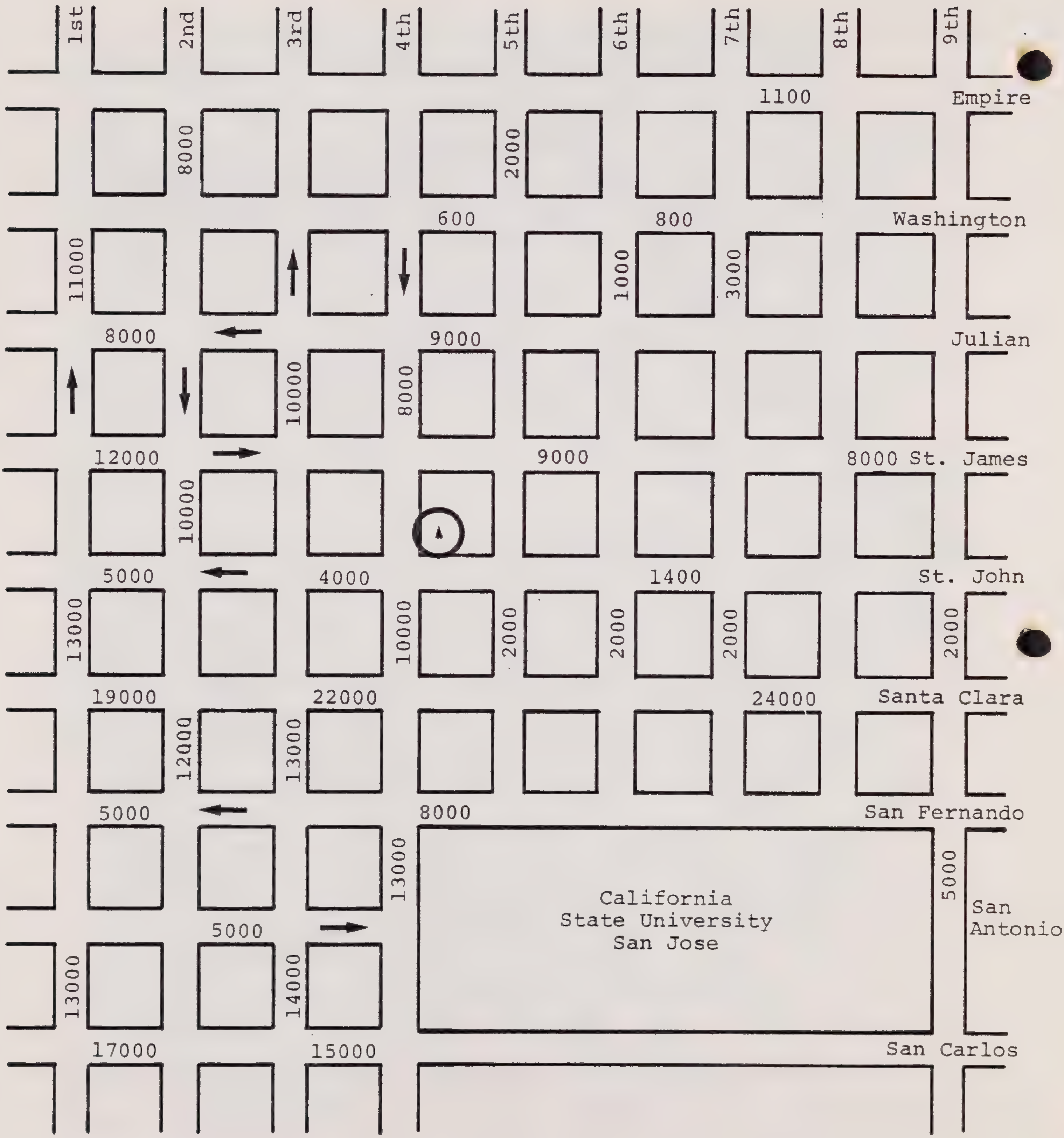


Figure 3 - SELECTED 24-HOUR TRAFFIC COUNTS IN SAN JOSE

(1973-1978)

Note: Not to scale.

- Widening and re-construction of San Fernando Street between Market and Fourth Streets to 90 feet and four moving lanes, two in each direction;

- Subsequent conversion of San Fernando Street between Fourth and Tenth Streets to two-way traffic and four moving lanes;

- Re-opening of West San Fernando Street beneath the Guadalupe Freeway viaduct to two-way traffic.

In addition to the redevelopment, a transit mobility improvement project is being developed in the San Jose CBD. The likely improvements include:

o First Street Transitway/Pedestrian Mall between St. James and San Carlos Streets (0.6 mile); centralized information booth/waiting room.

o Transit-Emphasis and Landscaping Improvements to San Fernando Street between Almaden Boulevard and Seventh Street; centralized information booth/waiting room.

SUNNYVALE

The Sunnyvale monitor was moved as of February 1978. This report describes the conditions around the original monitor site, since this is where the CO violations were recorded. The monitor was located in the central part of Sunnyvale on S. Murphy Avenue, a commercial street (see Figure 4). The street was two-lane and had older commercial buildings of 2-3 stories. A new shopping center is being built on this site.

Sunnyvale is typical of a number of cities in the northern Santa Clara Valley in that most of its employment centers are along Highway 101, on the north side of town, while its residents live on the south side. Thus there is heavy north-south commuting, and congested streets. One of these streets is Mathilda Avenue, 3 blocks west of the monitor. It carries more than 27,000 vehicles per day, (See Figure 5) and is the major commercial street in Sunnyvale. Sunnyvale Avenue, 1 block east of the monitor, carries about 7,000 vehicles. El Camino Real is a major east-west street, located about ½ mile south of the monitor. It carries about 22,000 vehicles daily.

As mentioned earlier, a major shopping center is being built on the site where the monitor had been located. This will likely increase traffic, particularly on Mathilda Avenue. However, the city is working on an

Figure 4 - Location of Air Quality Monitor in Sunnyvale

Daily Traffic Volumes
Figure 5

CITY OF SUNNYVALE
CALIFORNIA

TRAFFIC FLOW MAP
1977

DEPARTMENT OF

DATE

innovative staggered work hours program in an attempt to relieve congestion. All firms employing 50 or more workers have been requested to participate.

SAN FRANCISCO

The San Francisco monitor is in a commercial area just north of the Civic Center (See Figure 6). It is sited on the roof of the Air Quality Management District's building, approximately 8 stories above ground. Figure 7 presents 24 hour traffic counts on streets near the monitor and Figure 8 shows the evening peak-hour traffic. The Civic Center, just south of the monitor, is a major office center and thus significant commuter traffic passes near the monitor. Exhibition and entertainment centers are also located there. The Route 101 freeway terminates a few blocks southwest of the monitor and much of the traffic bound for the Golden Gate Bridge uses Franklin Street or Van Ness Avenue, which are on either side of the monitor. Van Ness also has extensive commercial development along the street. Geary Street, 4 blocks north of the monitor, handles a significant amount of east-west traffic.

There are no significant changes anticipated in the immediate vicinity of the monitor. Significant office development is occurring in downtown San Francisco, approximately a mile east of the monitor. The Yerba Buena Center, a major convention facility, will also be built in that area. Most of the new employees are expected to use transit, since parking is at a premium in the downtown area. However, there will be some new vehicle traffic, so some increase in volumes near the monitor can be expected.

OAKLAND

The Oakland monitor is located slightly east of the downtown area (see Figure 9) at the top of the State Building several stories above ground. It is in an area of government office building and small commercial establishments. There is fairly substantial traffic moving east on 11th Street and west on 12th Street, which connect with the underpass leading past the Municipal Auditorium and around Lake Merritt (See Figure 10). The Average Daily Traffic (ADT) on 11th Street is 7,400 vehicles with 23% occurring in the peak period of 4-6 P.M.. The ADT on 12th Street is approximately 13,000 vehicles, with 11% traveling in the 4-6 P.M. period (peak on 12th Street is in the morning).

Figure 6 - Location of Air Quality Monitor in San Francisco

CITY & COUNTY OF SAN FRANCISCO
TWENTY-FOUR HOUR TRAFFIC FLOW
ON PRINCIPAL STREETS & HIGHWAYS
1974-1976

Figure 7

CITY & COUNTY OF SAN FRANCISCO
EVENING PEAK HOUR TRAFFIC FLOW
ON PRINCIPAL STREETS & HIGHWAYS
1974 TO 1976

Figure 8

Figure 9 - Location of Air Quality Monitor in Oakland

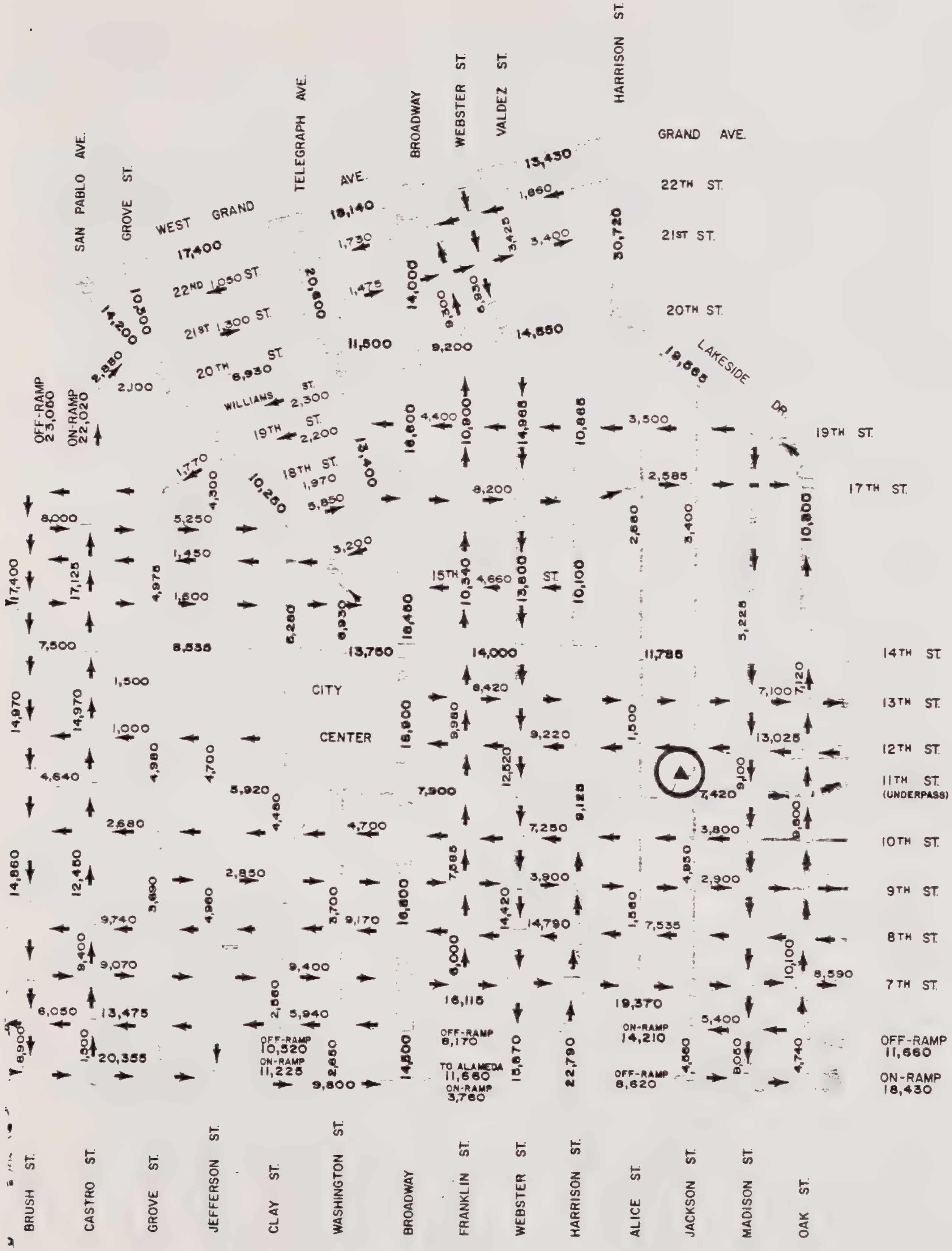


Figure 10 - City of Oakland
Traffic Flow Map
1976 ADT

The north-south streets that border the monitor are less heavily traveled, with 5,000 vehicles per day on Jackson Street and 1,500 vehicles per day on Alice Street. Fairly heavy east-west traffic also occurs on 14th Street (3 blocks away) and on 7th Street (4 blocks away). The one-way couplet of Madison and Oak Streets (1 and 2 blocks away) carries much of the north-south traffic as does Webster Street (2 blocks to the west) and the downtown streets immediately to the west of Webster. Figure 10 also shows the ADT on all the streets in the area. The Nimitz Freeway parallels 11th Street about ½ mile from the monitor location and carries an ADT of 126,000 vehicles as it crosses Jackson Street. There is an on-ramp at Jackson Street with an ADT of 14,000 vehicles and an off-ramp with an ADT of 5,000 vehicles.

Substantial commercial and residential development is planned in downtown Oakland. This will increase traffic in the area. Hong Kong U.S.A. is planned between 10th and 12th Streets and between Webster and Broadway just west of the monitor. This hotel/condominium/apartment/office complex is expected to generate considerable local traffic. The development will also result in the closing of 11th Street between Webster and Broadway. The Grove-Shafter Freeway presently ends near 18th Street in downtown Oakland. The completion of this freeway, connecting with the Nimitz Freeway and having several exits downtown, will bring more traffic to the area. The completion of the City Center commercial development in downtown Oakland will also generate increased traffic in the area. The City Center complex, which will include several large department stores and parking lots, is located ½ mile west of the monitor.

VALLEJO

The Vallejo monitor is located slightly east of the downtown area (See Figure 11), in a commercial neighborhood. It is in a 1-story building which houses legal and medical offices as well as a restaurant. The complex is in a small triangular block, and a small parking lot is located adjacent to the building. The county office building is across the street. The primary employment center in Vallejo is the Mare Island Shipyard. Since many of the residences, particularly the newer ones, are located in the eastern and northeastern areas of the city, there is a heavy east-west flow of work traffic. Much of this traffic uses Tennessee Street, since it connects with the causeway leading to Mare Island. The Average Daily Traffic (ADT) on this route between Tuolumne Street and I-80 is about 17,000 vehicles, with about 9% of these traveling in the peak hour of 4-5 p.m. The monitor borders on two fairly busy streets. Solano Avenue is a 4-lane facility with an ADT of 9,000, with about 12% of this traveling in the 4-5 p.m. peak hour. Tuolumne Street is also

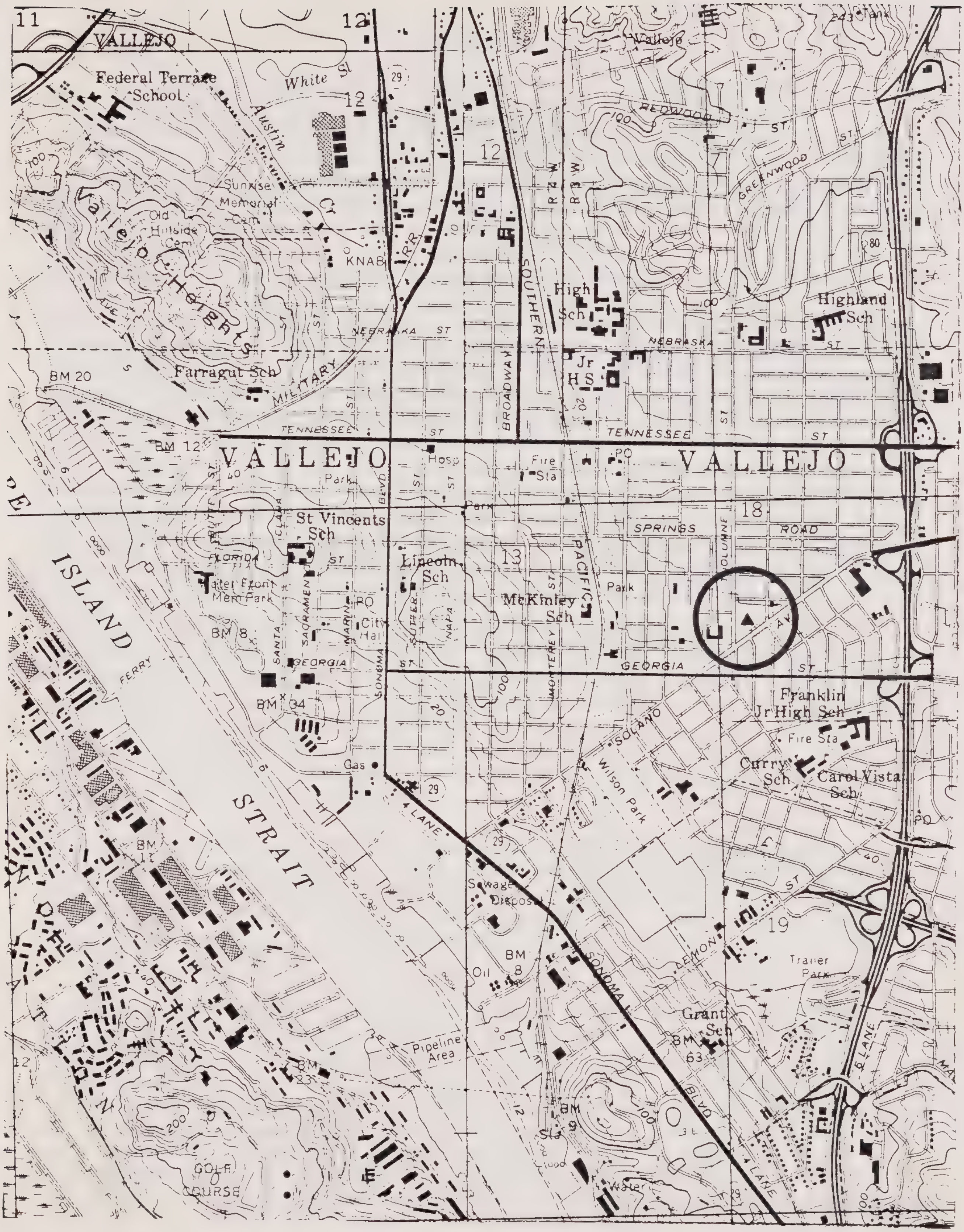


Figure 11 - Location of Air Quality Monitor in Vallejo

four-lane, has an ADT of 9,000 vehicles, with 9% of this in the evening peak hour. Capitol Avenue, the remaining street bordering on the monitor site, is a local two-lane facility. Georgia Street, a major east-west street, is about a block south of the monitor and carries about 10,500 vehicles per day, with about 8% of these in the evening peak hour. I-80 is about one-half mile east of the monitor. It has an annual ADT of 67,000 vehicles, with 7,900 during the peak hour.

Residential growth is continuing in the east and northeast sectors of Vallejo. This will probably result in heavier traffic volumes on Solano Avenue and other east-west streets. Downtown Vallejo, particularly near the waterfront, is undergoing partial redevelopment. This is likely to cause additional traffic, again primarily in an east-west direction. No significant street or highway system changes are contemplated in this area.

It is evident from the preceding descriptions that the locations where CO problems are found are not particularly unique. In fact, similar locations could undoubtedly be found in almost every city in the region. It is also evident that higher levels of carbon monoxide would probably be recorded if the sampling locations were adjacent to the busy streets and closer to street level.

Section – C

EXISTING CONTROL PROGRAMS AND ALTERNATIVE SOLUTIONS

This section discusses regulatory authorities for carbon monoxide controls in the Bay Area, existing control programs, and alternative control measures.

REGULATORY AUTHORITIES FOR CONTROL IN THE BAY REGION

Motor Vehicle Emission Controls — The California Air Resources Board (ARB) is the State agency responsible for coordinating both State and Federal air pollution control programs in California. This responsibility includes regulation of pollutant emissions from motor vehicles and coordination of local programs for stationary source control.

Due to the severity of air pollution problems in California, the Federal government gives the State the option of enforcing motor vehicle emission standards which are more stringent than Federal emission standards. Thus, while the Environmental Protection Agency takes primary responsibility for motor vehicle emissions control, the ARB can and has adopted and enforced emission standards more stringent than required at the Federal level.

Transportation Controls — There are many agencies with authority to implement transportation controls in the Bay Region: the Metropolitan Transportation Commission (MTC), the California Department of Transportation (Caltrans), transit districts and cities and counties. MTC is responsible for preparing the Regional Transportation Plan, for reviewing all State and Federally funded transportation projects, and for allocating transit funds. MTC also has the authority to set tolls on all transbay bridges except the Golden Gate Bridge.

Caltrans is responsible for modifications to the State highway system (e,g,, high occupancy vehicle lanes, ramp metering), State parking facilities and the State carpool program. Individual transit districts are responsible for implementing service improvements. Federal funds for these improvements are allocated by MTC. Certain controls such as parking and traffic controls are administered by local municipalities.

Air Quality Maintenance Plan — The Air Quality Maintenance Plan (AQMP) is a plan for reducing oxidant levels in the Bay Region over the next decade. It is contained in the Environmental Management Plan adopted by ABAG's member governments in June 1978. Many of that plan's transportation measures and vehicle emissions controls designed to reduce vehicle useage and emissions, respectively, also serve to reduce CO emission levels as well. Overall coordinating responsibility for Plan development and implementation and for the continuing planning process rests with the Association of Bay Area Governments. Participating agencies are the ones

named above and the Bay Area Air Quality Management District.

The authority to implement most of the AQMP recommendations currently exists among the various State, regional and local agencies as described previously. In a few instances, new legislation is required e.g. for an inspection and maintenance program for light and heavy duty vehicles and the heavy duty gasoline truck retrofit program.

EXISTING CONTROL PROGRAMS IN THE BAY AREA

Vehicle Emissions Controls — The ARB currently has regulations that control emissions from light, medium and heavy duty gasoline powered vehicles, diesel powered trucks and buses, and motorcycles. In addition, the CARB has in effect various regulations and procedures to ensure that emission standards are met. Table 4 presents current vehicle emission standards adopted by the ARB. Recently enacted Federal statutes are also presented for comparison.

Transportation Controls — The following transportation control projects are currently operating in the San Francisco Bay Area. Some were required as elements of the transportation control plan, while others are the result of regional transportation planning.

1. Ramp and Mainline Metering:

   I-580 - Beaumont Avenue eastbound on-ramp in Oakland;

   I-280 - 5 northbound on-ramps between Winchester Road and Route 85 in San Jose. Wolfe Road on-ramp provides bypass for buses and carpools of 2 or more.

   Rt. 101 - 5 northbound on-ramps between Capitol Avenue and Route 17 in Santa Clara County;

   Rt. 17 - 23 northbound and southbound on-ramps between Route 9 and Route 101 in Santa Clara County;

   Bay Bridge - In March 1974, an overhead metering system was installed just beyond the toll plaza at a cost of $350,000. This system has maximized the operational efficiency of the bridge.

The following project will be constructed soon:

   Rt. 101 - 5 northbound on-ramps between Route 17 and Fair Oaks Boulevard in Santa Clara County;

TABLE 4

NEW VEHICLE STANDARDS SUMMARY - PASSENGER CARS

Increasingly stringent standards for new passenger cars [1] have been imposed by State and Federal law. The following regulations apply to gasoline powered passenger cars only through 1979 and to gasoline and diesel powered cars beginning in 1980.

YEAR	STANDARD	TEST PROCEDURE	HYDRO-CARBONS	CARBON MONOXIDE	OXIDES OF NITROGEN
Prior to Controls	None	7-mode	850 ppm	3.4%	1000 ppm
		7-mode	11 gm/mi	80 gm/mi	4 gm/mi
		CVS-75	8.8 gm/mi	87.0 gm/mi	3.6 gm/mi
1966-67	Calif.	7-mode	275 ppm	1.5%	no std.
1968-69	Calif. or Federal	7-mode			
		50-100 CID	410 ppm	2.3%	no std.
		101-140CID	350 ppm	2.0%	no std.
		over-140CID	275 ppm	1.5%	no std.
1970	Calif. & Federal	7-mode	2.2 gm/mi	23 gm/mi	no std.
1971	Calif.	7-mode	2.2 gm/mi	23 gm/mi	4.0 gm/mi
	Federal	7-mode	2.2 gm/mi	23 gm/mi	no std.
1972	Calif.	7-mode or	1.5 gm/mi	23 gm/mi	3.0 gm/mi
		CVS-72	3.2 gm/mi	39 gm/mi	3.2 gm/mi (+)
	Federal	CVS-72	3.4 gm/mi	39 gm/mi	no std.
1973	Calif.	CVS-72	3.2 gm/mi	39 gm/mi	3.0 gm/mi
	Federal	CVS-72	3.4 gm/mi	39 gm/mi	3.0 gm/mi
1974	Calif.	CVS-72	3.2 gm/mi	39 gm/mi	2.0 gm/mi
	Federal	CVS-72	3.4 gm/mi	39 gm/mi	3.0 gm/mi
1975	Calif.	CVS-75	0.9 gm/mi (2)	9.0 gm/mi	2.0 gm/mi
	Federal	CVS-75	1.5 gm/mi	15 gm/mi	3.1 gm/mi
1976	Calif.	CVS-75	0.9 gm/mi (2)	9.0 gm/mi	2.0 gm/mi
	Federal	CVS-75	1.5 gm/mi	15 gm/mi	3.1 gm/mi
1977	Calif.	CVS-75	0.41 gm/mi	9.0 gm/mi	1.5 gm/mi
	Federal	CVS-75	1.5 gm/mi	15 gm/mi	2.0 gm/mi

Source: Air Resources Board, January 25, 1978

YEAR	STANDARD	TEST PROCEDURE	HYDRO-CARBONS	CARBON MONOXIDE	OXIDES OF NITROGEN
1978	Calif.	CVS-75	0.41 gm/mi	9.0 gm/mi	1.5 gm/mi
	Federal	CVS-75	1.5 gm/mi	15 gm/mi	2.0 gm/mi
1979	Calif.	CVS-75	0.41 gm/mi	9.0 gm/mi	1.5 gm/mi
	Federal	CVS-75	1.5 gm/mi	15 gm/mi	2.0 gm/mi
1980	Calif.	CVS-75	0.41gm/mi(3)	9.0 gm/mi	1.0gm/mi(1.5 gm/mi)
	Federal	CVS-75	0.41gm/mi	7.0 gm/mi	2.0 gm/mi
1981	(4)Calif.(A)	CVS-75	0.41 gm/mi	3.4 gm/mi	1.0 gm/mi(1.5 gm/mi)
	Calif.(B)	CVS-75	0.41 gm/mi	7.0 gm/mi	0.7 gm/mi
	Federal	CVS-75	(5)0.41 gm/mi	3.4 gm/mi	1.0 gm/mi
1982	(4)Calif.(A)	CVS-75	0.41 gm/mi	7.0 gm/mi	0.4gm/mi(1.0gm/mi)
	Calif.(B)	CVS-75	0.41 gm/mi	7.0 gm/mi	0.7 gm/mi
	Federal	CVS-75	(5)0.41 gm/mi	3.4 gm/mi	1.0 gm/mi
1983	Calif.	CVS-75	0.41 gm/mi	7.0 gm/mi	0.4gm/mi(1.0gm/mi)
	Federal	CVS-75	0.41 gm/mi	3.4 gm/mi	1.0 gm/mi

\+ Hot 7-mode test
1. Passenger car as defined in Title 13 of the California Administrative Code means any motor vehicle designed primarily for transportation of persons having a capacity of twelve persons or less.
2. Hydrocarbon emissions from 1975-76 limited production vehicles may not exceed 1.5 gm/mi.
3. Compliance with non-methane standard of 0.39 gm/mi is an acceptable alternative to the 0.41 gm/mi total hydrocarbon standard.
4. Manufacturer must choose one option (A or B) for the 1981-82 model years.
5. Federal CO standard can be waived to 7.0 for 1981-82 by administrator after public hearing.
6. Values in parenthesis are the standards which must be met by manufacturers choosing to certify their vehicles for 100,000 miles instead of the normal 50,000 mile distance.

Effective 1978, evaporative emission standards are 6 grams per SHED test for 1978-79 model year and 2 grams per SHED test for 1980 and later.

gm/mi - grams per mile
CVS-72 - a Constant Volume Sample cold start test.
CVS-75 - a Constant Volume Sample Test which includes hot & cold starts.
7-mode - 137 second driving cycle test.
ppm- parts per million
SHED Test - Sealed Housing Evaporative Determination for the testing of motor vehicle vapor recovery systems.

NEW VEHICLE STANDARDS SUMMARY - LIGHT DUTY TRUCKS

Increasingly stringent standards for Light-Duty Trucks [1] are imposed by State and Federal Law. The following is a summary of those regulations.

YEAR	STANDARD	TEST PROCEDURE	HYDRO-CARBONS	CARBON MONOXIDE	OXIDES OF NITROGEN
1966-67	Calif.	7-mode	275 ppm	1.5%	no std.
1968-69	Calif. or Federal	7-mode	410 ppm	2.3%	no std.
		50-100 CID	350 ppm	2.0%	no std.
		101-140CID	350 ppm	2.0%	no std.
		over-140CID	275 ppm	1.5%	no std.
1970	Calif. & Federal	7-mode	2.2 gm/mi	23 gm/mi	no std.
1971	Calif.	7-mode	2.2 gm/mi	23 gm/mi	4.0 gm/mi
	Federal	7-mode	2.2 gm/mi	23 gm/mi	no std.
1972	Calif.	7-mode or	1.5 gm.mi	23 gm/mi	3.0 gm/mi
		CVS-72	3.2 gm/mi	39 gm/mi	3.2 gm/mi +
	Federal	CVS-72	3.4 gm/mi	39 gm/mi	~~no~~ std.
1973	Calif.	CVS-72	3.2 gm/mi	39 gm/mi	3.0 gm/mi
	Federal	CVS-72	3.4 gm/mi	39 gm/mi	3.0 gm/mi
1974	Calif.	CVS-72	3.2 gm/mi	39 gm/mi	2.0 gm/mi
	Federal	CVS-72	3.4 gm/mi	39 gm/mi	3.0 gm/mi
1975	Calif.	CVS-75	2.0 gm/mi	20 gm/mi	2.0 gm/mi
	Federal	CVS-75	2.0 gm/mi	20 gm/mi	3.1 gm/mi
1976	Calif.	CVS-75	0.9 gm/mi	17 gm/mi	2.0 gm/mi
	Federal	CVS-75	2.0 gm/mi	20 gm/mi	3.1 gm/mi
1977	Calif.	CVS-75	0.9 gm/mi	17 gm/mi	2.0 gm/mi
	Federal	CVS-75	2.0 gm/mi	20 gm/mi	3.1 gm/mi

TABLE 4 (continued)

LIGHT DUTY TRUCKS

YEAR	STANDARD	TEST PROCEDURE	HYDRO-CARBONS	CARBON MONOXIDE	OXIDES OF NITROGEN
1978(2)	Calif.	CVS-75	0.9 gm/mi	17 gm/mi	2.0 gm/mi
	Federal	CVS-75	2.0 gm/mi	20 gm/mi	3.1 gm/mi
1979	Calif.(3)	CVS-75	0.41 gm/mi	9.0 gm/mi	1.5 gm/mi
	Calif.(4)	CVS-75	0.50 gm/mi	9.0 gm/mi	2.0 gm/mi
1979 (5)	Federal & later	CVS-75	1.7 gm/mi	18 gm/mi	2.3 gm/mi
1980	Calif. (3)	CVS-75	0.41 gm/mi(6)	9.0 gm/mi	1.5gm/mi (1.0gm/m
	Calif. (4)	CVS-75	0.50 gm/mi	9.0 gm/mi	2.0gm/mi (2.3gm/m
1981-82	Calif. (3)	CVS-75	0.41 gm/mi	9.0 gm/mi	1.0gm/mi (1.5gm/m
	Calif. (4)	CVS-75	0.50 gm/mi	9.0 gm/mi	1.5 gm/mi(2.0gm/m
1983 & later	Calif. (3)	CVS-75	0.41 gm/mi	9.0 gm/mi	0.4gm/mi (1.0gm/mi
	Calif. (4)	CVS-75	0.50 gm/mi	9.0 gm/mi	1.0gm/mi(1.5gm/mi)

\+ Hot 7-mode test

1. Light duty trucks as defined by Title 13 of the California Administrative Code means any motor vehicle rated at 6000 lbs. GVW or less which is designed primarily for purposes of transportation of property or is a derivative of such vehicle, or is available with special features enabling off-street or off-highway operation and use.
2. The standards apply to both gasoline and diesel powered vehicles for 1978 and later years.
3. 0-3999 pounds equivalent inertia weight.
4. 4000-6000 pounds equivalent inertia weight.
5. Effective 1979, Federal LDT classification will be extended to 8500 GVW.
6. Compliance with non-methane standard of 0.39 gm/mi is an acceptable alternative to California's 0.41 gm/mi standard.
7. Values in parenthesis give manufacturers the option to certify their vehicles at stricter standards for 50,000 miles or less stringent standards for 100,000 miles.

Effective 1978, evaporative emission standards are 6 grams per SHED test for 1978-79 model years and 2 grams per SHED test for 1980 and later.

gm/mi - grams per mile   ppm- parts per million

7-mode - 137 second driving cycle test

CVS-72 - a Constant Volume Sample cold start test.

CVS-75 - a Constant Volume Sample Test which includes hot & cold starts.

TABLE 4 (continued)

NEW VEHICLE STANDARDS SUMMARY MEDIUM DUTY VEHICLES

Increasingly stringent standards for medium duty vehicles[1] have been imposed by State and Federal law. The following is a summary of the regulations starting with the 1969 model year.

YEAR	STANDARD	TEST PROCEDURE	HYDRO-CARBON	CARBON MONOXIDE	OXIDES OF NITROGEN (7)
1969-77	Calif.	SEE HEAVY DUTY STANDARD FOR 1969-1977			
1973-78	Federal	SEE HEAVY DUTY STANDARD FOR 1973-1978			
1978 (2)	Calif.	CVS-75	0.9 gm/mi	17 gm/mi	2.3 gm/mi
1979	Calif.	CVS-75	0.9 gm/mi	17 gm/mi	2.3 gm/mi
	Federal	SEE LIGHT-DUTY TRUCK STANDARDS FOR 1979 and LATER			
1980	Calif.	CVS-75	0.9 gm.mi	17 gm/mi	2.3 gm/mi
1981-82	Calif.(3)	CVS-75 (6)	0.41 gm/mi	9.0 gm/mi	1.0gm/mi (1.5gm/
	Calif.(4)	CVS-75	0.50 gm/mi	9.0 gm/mi	1.5gm/mi (2.0gm/
	Calif.(5)	CVS-75	0.60 gm/mi	9.0 gm/mi	2.0gm/mi (2.3gm/
1983 & later	Calif.(3)	CVS-75	0.41 gm/mi	9.0 gm/mi	0.4gm/mi (1.0gm/m
	Calif.(4)	CVS-75	0.50 gm/mi	9.0 gm/mi	1.0gm/mi (1.5gm/m
	Calif.(5)	CVS-75	0.60 gm/mi	9.0 gm/mi	1.5gm/mi (2.0gm/mi

1. Medium duty vehicles as defined in Title 13 of the California Administrative Code means any heavy-duty vehicle having a manufacturers' GVW rating of 8500 pounds or less (Manufacturers may elect to certify medium-duty vehicles up to 10,000 lbs GVW).
2. The standards apply to both gasoline and diesel powered vehicles for 1978 & later years.
3. 0-3999 equivalent inertia weight.
4. 4000-6000 equivalent inertia weight.
5. 6001-8500 equivalent inertia weight.
6. Compliance with non-methane standard 0.39 gm/mi is an acceptable alternative to California's 0.41 gm/mi standard.
7. Values in parenthesis give manufacturers option to certify their vehicles at the stricter standard for 50,000 miles or the less stringent standard for 100,000 miles.

Effective 1978, evaporative emission standards are 6 grams per SHED test for 1978-79 model years and 2 grams per SHED test for 1980 and later.

gm/mi - grams per mile

CVS-75 - a Constant Volume Sample test which includes hot & cold starts.

(TABLE 4 (continued)

NEW VEHICLE STANDARDS SUMMARY - MOTORCYCLES

The following is a summary of motorcycle[1] standards adopted by both the Air Resources Board and the Federal Environmental Protection Agency.

MODEL YEAR	STANDARD	DISPLACEMENT[2]	HYDROCARBONS	CARBON MONOXIDE
1978-79	Calif. & Federal	50-169	5.0 gm/km	17 gm/km
		170-749	5.0 +0.0155gm/km (D-170) (3)	17 gm/km
		750 & larger	14 gm/km	17 gm/km
1980-81	Calif.	All 50 & Larger	5.0 gm/km	12 gm/km
1980 & Later	Federal	All 50 & larger	5.0 gm/km	12 gm/km
1982 & later	Calif.	All 50 & larger	1.0 gm/km	12 gm/km

1. Any motor vehicle other than a tractor having a seat or saddle for the use of the rider and designed to travel on not more than three wheels in contact with the ground and weighing less than 1500 pounds, except that four wheels may be in contact with the ground when two of the wheels function as a sidecar.
2. Displacement shown in cubic centimeters.
3. Motorcycle Hydrocarbon Formula:
   170 cc to less than 300 cc 5.0 + 0.0155 (D-170)
   i.e., 300 cc - 170 cc = 130 cc X 0.0155 + 2.0150 + 5.0 = 7.01 gm/km standard.

gm/km - grams per kilometer

TABLE 4 (continued)

NEW VEHICLE STANDARDS SUMMARY - HEAVY DUTY VEHICLES (DIESEL (1) AND GASOLINE)

Increasingly stringent standards for new heavy duty vehicles[2] have been imposed by State and Federal law. The following is a summary of the regulations starting with the 1969 model year.

YEAR	STANDARD	HYDRO-CARBONS	CARBON MONOXIDE	OXIDES OF NITROGEN	HYDROCARBONS & OXIDES OF NITROGEN
1969-71 (3)	Calif.	275 ppm	1.5%	-	-
1972	Calif.	180 ppm	1.0%	-	-
1973-74	Calif.	-	40 gm/BHP hr	-	16 gm/BHP hr
1973-78	Federal	-	40 gm/BHP hr	-	16 gm/BHP hr
1975-76	Calif.	-	30 gm/BHP hr	-	10 gm/BHP hr
1977-78	Calif. or	-	25 gm/BHP hr		5 gm/BHP hr
	Calif.	1.0 gm/BHP hr	25 gm/BHP hr	7.5 gm/BHP	-
1979(4)	Calif. or	1.5 gmBHP hr	25 gm/BHP hr	7.5 gm/BHP hr	
	Calif.		25 gm/BHP hr	-	5 gm/BHP hr
1979 & later	Federal or	1.5 gm/BHP hr	25 gm/BHP hr	-	10 gm/BHP hr
	Federal	-	25 gm/BHP hr	-	5 gm/BHP hr
1980-82	Calif. or	1.0 gm/BHP hr	25 gm/BHP hr	-	6.0 gm/BHP hr
	Calif.	-	25 gm/BHP hr	-	5 gm/BHP hr
1983 & later	Calif.	0.5 gm/BHP hr	25 gm/BHP hr	-	4.5 gm/BHP hr

1. The diesel standard was not effective in California until January 1, 1973 and nationwide January 1, 1974.

2. Any motor vehicle having a manufacturer's GVW rating of over 6000 pounds except a passenger car.

3. Applies to vehicles manufactured on or after January 1, 1969.
4. Use of flame ionization detector in 1979 and later years will result in higher HC readings than the non-dispersive infra-red instrumentation currently in use. For 1979 only, California's HC standard is 1.0 gm/BHP hr and the Federal standard 1.1 gm/BHP hr for gasoline engines using the non-dispersive infra-red instrumentation.

gm/BHP hr - grams per brake horsepower hour

2. Preferential Bus/Carpool Lanes on Freeways:

Rt. 101 - Marin County Exclusive Bus Lanes. In 1972, a 3.9 mile northbound contra-flow exclusive bus lane was opened just north of the Golden Gate Bridge for use during the period 4 to 7 p.m. Approximately 100 buses use the lane, carrying about 4500 persons. In 1974 the project was extended north an additional 3.8 miles when concurrent-flow bus lanes were opened in both directions. Carpools were later allowed to use these lanes.

Rt. 280 - In October 1975, a two mile bus/carpool lane was opened on southbound I-280 in San Francisco from Sixth Street to approximately one-half mile south of Army Street. Approximately 200 carpools and 12 buses use this lane during the evening peak.

Rt. 580 - A bus/carpool lane is open through the Dublin Canyon. A study of the feasibility of extending this to the Bay Bridge is underway.

S.F. - In San Francisco bus lanes are in operation on Post and Sutter Streets between Van Ness and Taylor. Approximately 60 buses use these lanes during the peak periods. Muni has reported improved schedule adherence. A bus lane has also opened along Mission Street.

3. Toll Incentives:

Bay Bridge - In December 1971, with flow carpool and bus lanes were opened at the westbound approach of the toll plaza. In 1975 carpool tolls were eliminated. During the 6 to 9 a.m. peak period, 430 buses and 2,200 carpools use the priority lane.

San Mateo-Hayward and Dumbarton Bridges - Toll free preferential lanes for buses and carpools were opened on both these bridges. Approximately 52 carpools and 40 buses use these lanes during commute periods.

Golden Gate Bridge - The Golden Gate Bridge District began allowing carpools to use the bridge toll-free in 1976. Approximately 1100 carpools use this lane.

Toll Revenues - AB 664 gave the Metropolitan Transportation Commission authority over the level and use of tolls on the trans-bay bridges. The Commission has recently raised the tolls and is using the excess revenue for transit.

4. Carpool Matching Program:

RIDES - is a program operated by Caltrans District 04 to promote carpooling in the San Francisco Bay Area. A non-profit corporation funded by Caltrans, the Federal Energy Administration and Metropolitan Transportation Commission, has been established to expand this program. A survey conducted in 1975 indicated that approximately 5000 persons had formed carpools as a result of the program.

5. Improvement of Transit Service:

AC/BART - Coordinated Fare - The AC/BART transfer system provides for free transfers from BART to AC.

MUNI/BART Coordinated Fare - The MUNI/BART transfer system provides two tickets for MUNI bus rides for 25¢, a savings of one-half the full regular fare.

Santa Clara - Santa Clara Transit District was formed in 1972. Operations commenced in 1975 with 233 buses. The District also operated 9 buses for "Commute Specials"--these are used by some of the corporations.

Bus Pre-emption - A bus pre-emption system is to be installed along a portion of Almaden Expressway. Twelve signalized intersections are involved. The traffic signal equipment is under construction.

San Mateo County - San Mateo Transit District was formed in 1974 and operations commenced in July 1976. Two hundred buses provide service to and within most cities in San Mateo County including a connecting service between most cities in San Mateo County including a connecting service between the Daly City BART station and San Francisco Airport. Buses also serve Southern Pacific Stations in the county.

Marin County - In 1970 Golden Gate Transit introduced a new ferry service between Sausalito and San Francisco. Additional service was added in December 1976 between Larkspur and San Francisco.

Napa County - Napa County introduced a Dial-A-Ride system which is designed to provide local transit service in three communities: St. Helena, Calistoga and Napa. The service is provided using one bus.

Sonoma - Mini-bus operates in Sebastopol. Transit service in Santa Rosa is provided by 13 buses, which operate approximately 40 minutes apart.

Solano - In August 1975, the City of Fairfield implemented a Dial-A-Ride program using 5 vans. The service area is seven square miles with a population of 40,000.

AC Transit - AC Transit now provides contract city services in Concord, Pleasant Hill, and Moraga/Orinda. AC Transit also connects with Santa Clara County Transit District buses at Fremont BART station.

6. Preferential Parking:

San Francisco - Caltrans is in the process of leasing 4 state parking lots for carpool use. There would be 580 stalls available, open only to carpools of 3 or more. The fee would be not more than $10/month.

The experience with transportation programs is valuable. The carpool incentives seem to be successful. The transit additions are also rather significant, but the problems of financing are becoming critical.

ALTERNATIVE CONTROL MEASURES

As previously identified in the adopted Air Quality Maintenance Plan for the region, there are a number of alternative control measures that could act to reduce CO emissions. Since roughly 90 percent of carbon monoxide emissions are from motor wehicle exhaust, the most appropriate types of controls to consider are motor vehicle emission controls and transportation controls.

CO emissions occur primarily during engine start-up (e.g., cold start and hot start emissions) and while the vehicle is in operation (hot stabilized). In addition, the emission rate varies substantially with speed, being greatest when the vehicle is idling or operating at low speeds such as those occuring under congested, stop-and-go traffic conditions. The exhaust catalyst tech-

nology in use on post-1974 model year automobiles is most effective in reducing emissions during hot stabilized engine operation. As the number of vehicles with catalyst systems increases, the primary component of CO emissions will shift from the hot stabilized to the cold start.

Motor Vehicle Emission Controls — Further controls on light and heavy duty vehicles beyond those now in effect or scheduled for implementation consist of the following:

- More stringent new vehicle emission standards
- Exhaust retrofit for heavy duty gasoline vehicles
- Mandatory annual inspection and maintenance program
- More stringent certification of compliance procedures
- More comprehensive new motor vehicle surveillance program
- Emission standards for other mobile sources

These control alternatives have been previously described in the adopted Air Quality Maintenance Plan.

Transportation Controls — Reducing the need to travel by motor vehicle is one way to reduce CO emissions. Another approach is to reduce congestion, expedite traffic flow, and thus raise vehicle speeds. Since CO problems are localized, it may also be possible to reduce ambient CO levels by spreading or dispersing traffic without necessarily reducing emissions. The transportation control alternatives for reducing ambient CO levels are thus formulated to satisfy one of two policy goals: to reduce vehicle use, or to improve traffic flow, as listed in Table 5.

Table 5. ALTERNATIVE TRANSPORTATION CONTROLS

Policy: Reduce Vehicle Usage

- better enforcement of parking regulations
- limit number of parking spaces
- prohibit on-street parking during peak hours
- area license
- auto-free zones
- gas rationing
- road-pricing
- increased parking costs
- provide pedestrian amenities
- provide bicycle facilities
- toll reduction for carpools
- preferential parking for carpools
- carpool-vanpool matching program
- eliminate free employee parking
- additional gasoline tax
- increased tolls
- goods movement consolidation
- additional transit service
- improved transit comfort
- bus/carpool lanes
- land use/growth management
- auto fees

Policy: Improve Traffic Flow

- encourage carpooling and transit usage
- staggered work hours
- ramp-metering
- auto-control zones
- computerized traffic control
- traffic engineering improvements
- off-street freight loading
- off-peak freight loading

Section - D

FUTURE PROSPECTS AND CONTROL STRATEGY ANALYSIS

The technical analysis of future CO problems is complicated by four factors:

- extremely localized character of CO variations
- poor performance of available analysis tools (models)
- high sensitivity of CO emission factors to average speed estimates
- uncertainty in projected CO emission factors for motor vehicles

The uncertainty in projected CO emission factors for motor vehicles is illustrated by the fluctuation such factors have undergone over the past two years. Table 6 summarizes recent changes in CO emission factors applicable in California. The first column contains base year (1975) and projected future emission factors based on EPA's original Supplement 5 to AP-42.* The second and third columns summarize comparable emission factors from EPA's draft Supplement 8 to AP-42 (released in June, 1977), and its subsequent version, Revised Supplement 5 to AP-42 (released January 1978).** The fourth column summarizes an alternative set of CO emission factors that the California Air Resources Board (CARB) has developed. CARB is in the process of applying to EPA for approval of this alternative set of factors. The crucial aspects of this table are the remarkable differences between projected future year composite emission factors, hence the uncertainty of projecting future CO emissions.

The localized microscale character of CO problems means that proper analysis should be conducted on a localized basis. There are several air quality models from which to choose, each of varying degrees of sophistication and data requirements. Table 7 summarizes the models in common use, including one recently developed model (the Lagrangian Roadway Model), in terms of their advantages and disadvantages. Given the existing monitoring network in the Bay Area, the linear rollback model would probably substantially underestimate the magnitude of the problem and thus the degree of control necessary to achieve the CO standards. The Gaussian line source models inherently contain assumptions of steady-state, uniform meteorological conditions and emission rates, which are difficult to justify either in complex terrain or for an 8-hour computation period. EPA's HIWAY model in particular has been found to significantly overestimate CO levels under light wind and stable atmospheric conditions. The Eulerian grid models (e.g., LIRAQ)

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* EPA, "Compilation of Air Pollutant Emission Factors," AP-42, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, 27711, April 1973.

** EPA, "Mobile Source Emission Factors," final document, Office of Transportation and Land Use Policy, Washington, D.C. 20460, January 1978.

TABLE 6 CARBON MONOXIDE EMISSION FACTORS (gms/mile)

1975	Supp 5 (1974)[a]	Draft Supp 8 (June 1977)[a]	Rev Supp 5 (Jan.1978)[b]	CARB[b]
LDA	46.7	52.3	57.8	58.3
LDT	54.2	58.0	60.1	59.6
HDG	207.2	272.1	260.8	186.9
HDD	28.7	32.2	32.5	23.7
Composite	59.2	69.0	72.6	67.0
1985				
LDA	5.7	17.8	16.2	13.9
LDT	16.2	18.8	23.2	22.7
HDG	144.2	234.3	179.2	97.3
HDD	28.7	21.7	28.2	22.2
Composite	18.4	34.6	29.9	21.6
1995/2000				
LDA	3.7	18.1	12.9	9.5
LDT	11.8	17.5	14.8	13.0
HDG	122.2	233.6	97.5	54.3
HDD	28.7	19.9	27.1	19.9
Composite	14.7	34.5	20.1	13.7

LDA - light duty automobiles
LDT - light duty trucks
HDG - heavy duty gasoline powered trucks
HDD - heavy duty diesel powered trucks

[a] Source: Letter from Daniel Lieberman, California Air Resources Board, to Eugene Leong, Association of Bay Area Governments, July 12, 1977. Subject: Supplement 8 Emission Factors

[b] Source: California Air Resources Board Memorandum from William C. Lockett to All AQMP Task Forces, Jack T. Kassel and George Hill, Caltrans, March 28, 1978; Subject: Motor Vehicle Emission Estimates for Planning

TABLE 7. SUMMARY OF SELECTED CO MODELING APPROACHES

Modeling Approach	Advantages	Disadvantages
Linear rollback (Reference 8)	- fast and simple to apply - minimal input data requirements	- relies on existing monitoring data to prescribe control levels - ignores future changes in spatial and temporal patterns of emissions - difficult to validate
Gaussian line source (References 9 and 10) e.g., HIWAY CALINE-2 APRAC-II	- with certain assumptions, can address microscale peaks - simple to apply	- requires microscale traffic data for input - urban background CO levels difficult to obtain - assumptions of steady-state and uniform meteorology are not valid for 8-hour simulations or in cases of topography common in the Bay Area - some validation work required
Eulerian grid (Reference 11) e.g., LIRAQ	- can address urban background CO levels - input data previously prepared - accepts non-steady state and non-uniform meteorology and emission data	- cannot address microscale peaks - some validation work required
Lagrangian roadway (Reference 12)	- state-of-the-art microscale roadway model - accepts non-steady state and non-uniform meteorological data	- validation required - requires microscale traffic data for input - urban background CO levels difficult to obtain - more complex and expensive than Gaussian line source models

inherently contain a substantial degree of spatial averaging of emissions and would thus be insensitive to the microscale peaks which are characteristic of ambient CO levels in the region. LIRAQ can, because of the regional coverage afforded by its grid, be used to define appropriate values for urban background CO levels across the region. Finally, the Lagrangian roadway model has been specifically developed to be applied on a microscale basis and is technically superior in its formulation to the Gaussian line source models. Thus, the most promising approach to modeling CO in the Bay Area consists of a combination of the LIRAQ model to simulate urban background levels, and the Lagrangian roadway model to simulate microscale CO peaks near roadways. When run under the same meteorogical conditions, the results of the two models may be superimposed to obtain a more complete picture of CO levels at a given location.

This approach would utilize the most sophisticated air quality analysis methods currently available and would require that concomitant traffic data at similar scales be collected for input. A crucial aspect of this traffic data is the average speed. Table 8 summarizes the variation of CO emission factors as a function of speed for light and heavy duty vehicles. The emission factors previously shown in Table 6 are multiplied by these speed correction factors. For example, the CO emission rate for light duty vehicles at 10 miles per hour is approximately double the rate shown in Table 6. This high sensitivity of CO emission factors to estimates of projected average vehicle speeds means that detailed, hourly, block-by-block traffic projections would be needed at each problem location. At the present time it is unclear whether such traffic forecasts could be made with a reasonable level of confidence.

Each of these preceding factors suggests the need for more in-depth analysis of CO problems than is possible at this time. The tasks to be undertaken as part of the continuing planning process for CO are directed toward producing the necessary in-depth analyses, and are included as part of this plan. To satisfy the minimum requirements for CO plan analysis, the current plan has been based on the linear rollback model using EPA revised Supplement 5 (AP-42) emission factors.

Control Strategy Analysis

Table 9 summarizes the baseline CO emission inventory projection for various years. From this table, it may be seen that despite steady increases in vehicle-miles-travelled, substantial reductions in CO emissions will continue through 1987 as a result of ongoing State motor vehicle emission control programs.

The linear rollback model requires the use of the maximum 1-hour or 8-hour average Co level recorded. Since there have been no violations of the 1-hour standard recorded by Bay Area Air Quality Management District (BAAQMD) urban air monitoring stations, the maximum 8-hour average value of 20.2 ppm at San Jose was used:

$$\text{Percent CO emission reduction required} = \frac{20.2\text{ ppm} - 9\text{ ppm}}{20.2\text{ ppm}} = 55.4\%$$

Before considering additional controls for carbon monoxide, the CO emission reductions due to control programs already adopted as part of the Bay Area's oxidant plan were evaluated. Tables 10 and 11 summarize the results of that evaluation. It may be seen that attainment of the CO standard (according to linear rollback) may be achieved by 1984. Lead times necessary to implement each of the control programs shown make attainment by 1982 highly unlikely. Therefore, an extension of the attainment date beyond 1982 is requested. The control programs previously adopted will, according to the linear rollback analysis, provide emission reductions sufficient to meet the CO standards. Additional data and analysis will be evaluated for subsequent plan updates, and additional controls will be proposed as needed.

TABLE 8

SPEED CORRECTION FACTORS FOR CARBON MONOXIDE (LOW ELEVATION)

SPEED	LIGHT-DUTY AUTOS AND TRUCKS	HEAVY-DUTY GASOLINE TRUCKS	HEAVY-DUTY DIESEL TRUCKS
5	4.185	3.070	1.193
6	3.486	2.616	1.149
7	2.987	2.293	1.117
8	2.613	2.050	1.093
9	2.322	1.861	1.074
10	2.089	1.710	1.059
11	1.898	1.586	1.047
12	1.739	1.483	1.037
13	1.605	1.396	1.029
14	1.490	1.321	1.021
15	1.284	1.227	1.015
16	1.214	1.171	1.009
17	1.149	1.119	1.004
18	1.083	1.070	1.000
19	1.033	1.025	.939
20	.981	.984	.884
21	.933	.944	.834
22	.888	.908	.789
23	.847	.874	.748
24	.808	.842	.710
25	.772	.813	.675
26	.739	.785	.643
27	.708	.759	.613
28	.679	.735	.586
29	.652	.713	.560
30	.627	.692	.536
31	.604	.673	.514
32	.582	.654	.493
33	.561	.638	.473
34	.542	.622	.454
35	.525	.607	.437
36	.508	.594	.420
37	.493	.581	.404
38	.478	.570	.390
39	.465	.559	.376
40	.453	.549	.362
41	.441	.540	.349
42	.430	.532	.337
43	.420	.524	.326
44	.411	.518	.315
45	.403	.512	.304

SOURCE: California Department of Transportation, "Motor Vehicle Emission Factors for Estimates of Highway Impact on Air Quality," August 1976.

Table 9. BASELINE CARBON MONOXIDE EMISSION PROJECTION

Year	Composite Emission Factor (gms/mi.)[a]	Daily vehicle miles traveled	CO Emissions (tons/day) Motor vehicles	Other sources	Total
1975	72.6	68,608,127	5486	467	5953
1979	52.2	75,529,191[b]	4342	498	4840
1980	47.9	77,259,457[b]	4076	501	4577
1981	43.8	78,989,723[b]	3810	515	4325
1982	39.9	80,719,989[b]	3547	517	4064
1983	36.2	82,450,255[b]	3287	533	3820
1984	32.6	84,180,521[b]	3022	537	3559
1985	29.9	85,910,789	2829	538	3367
1986	27.6	87,978,592[b]	2674	555	3229
1987	25.8	90,046,395[b]	2559	571	3130
2000	20.1	116,927,835	2588	653	3241

[a] assumes 19.6 mph average speed, 75^{o} F ambient temperature, 20% cold start operation, 27% hot start operation, no trailer towing, hill climbing or air conditioning corrections applied.

[b] linear interpolation

Table 10. CONTROL STRATEGY EFFECTIVENESS

Control	Percent CO Emission Reduction from 1975 Total		
	1982	1985	2000
Baseline (includes effects of growth and ongoing control programs)	32%	43%	46%
Inspection/maintenance	-	9%[a]	12%
Heavy-duty gas truck retrofit	-	11%[a]	-
Transportation controls	1%	3%[a]	3%[b]
TOTAL	33%	66%	61%

[a] With an emission reduction target of 55.4% prescribed by linear rollback, only two of these three programs would be necessary to attain the CO standards. To qualify for an extension of the attainment deadline beyond 1982, however, each of these programs should be included in the plan.

[b] Transportation controls are not necessary for long term maintenance of CO standards according to the linear rollback analysis.

Table 11. EFFECTIVENESS OF TRANSPORTATION CONTROLS

Program	Vehicle Activity Reduction		% Emission Reduction
	Trips	Vehicle Miles Traveled	
Preferential Parking For Carpools	0.1%	0.1%	0.1%
Transit Service Increase	0.8%	0.9%	0.8%
Bus/Carpool Lanes & Ramp Metering	0.1%	0.1%	0.1%
Ride Sharing	0.9%	1.2%	0.9%
Bicycle Systems	1.8%	0.6%	1.1%
Total Effectiveness			3%

Section - E

PLAN RECOMMENDATIONS

The primary focus of this plan submission is the commitment to conduct a detailed assessment of known and suspected carbon monoxide problem areas within the region. Because CO is a localized problem, which probably occurs in many areas throughout the region, and because traffic controls may contribute to their alleviation, local cities and counties must be actively involved in the planning and implementation of Carbon Monoxide controls. It is anticipated that ABAG, MTC and BAABMD will be the focus of the technical analysis and evaluation of potential control measures - but that individual cities will share responsibility for adopting and implementing controls.

No new controls are proposed in this plan. Many of the controls which were adopted as part of the oxidant plan would also reduce CO emissions to the degree necessary to demonstrate "reasonable further progress" toward attainment of CO standards. These controls are summarized in this section.

The plan recommendations are summarized in Table 12. For each action listed in the first column, subsequent columns of the table indicate the agencies responsible for implementing the action, the implementation schedule, costs, sources of financing, direct benefits in terms of emission reductions, and other environmental, institutional/financial, economic, and social impacts of the action.

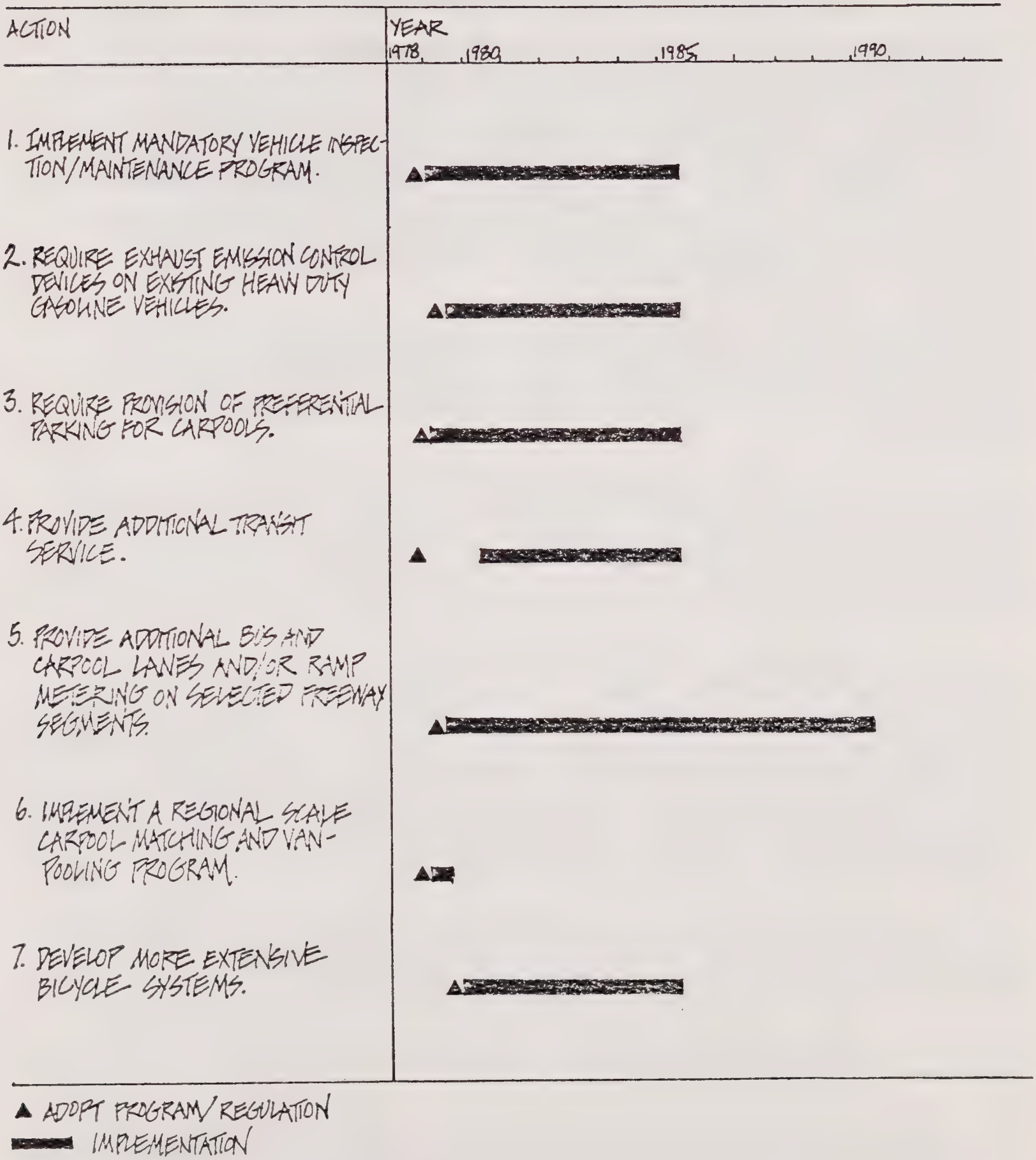
Figure 11 highlights in graphic form the schedule for implementation of each of the plan recommendations. Most of the recommendations could be adopted by appropriate agencies within two years of plan approval. However, full implementation would realistically require several years beyond the adoption phase, particularly for the most significant programs such as the inspection/maintenance program. It is therefore unlikely that the carbon monoxide standard can be met in the Bay Area by 1982. Figure 12 summarizes the projected progress toward meeting the CO standards, and indicates that attainment can be expected by 1984 if all plan recommendations are implemented.

The following narrative provides background information for the recommended actions. All actions recommended for control of CO emissions were adopted to control hydrocarbon emissions by ABAG's General Assembly in June 1978. No new actions beyond those adopted in the AQMP are included in this plan.

Action 1: Implement a mandatory annual inspection and maintenance program for light and heavy duty vehicles.

While automobile emissions can be controlled by a variety of basic engine modifications and exhaust treatment devices, the state of tune of the vehicle also affects emissions significantly, regardless of what emission standards the vehicle was originally designed to meet. An incorrectly adjusted idle air/fuel ratio can double carbon monoxide emissions. Defective emission control components can cause the emissions of late model cars to equal those of uncontrolled vehicles. A program for identification and repair of vehicles with excessive emissions caused by maladjusted or defective components has the potential to significantly reduce automotive emissions.

FIGURE 11
SCHEDULE FOR IMPLEMENTATION OF THE CARBON MONOXIDE PLAN



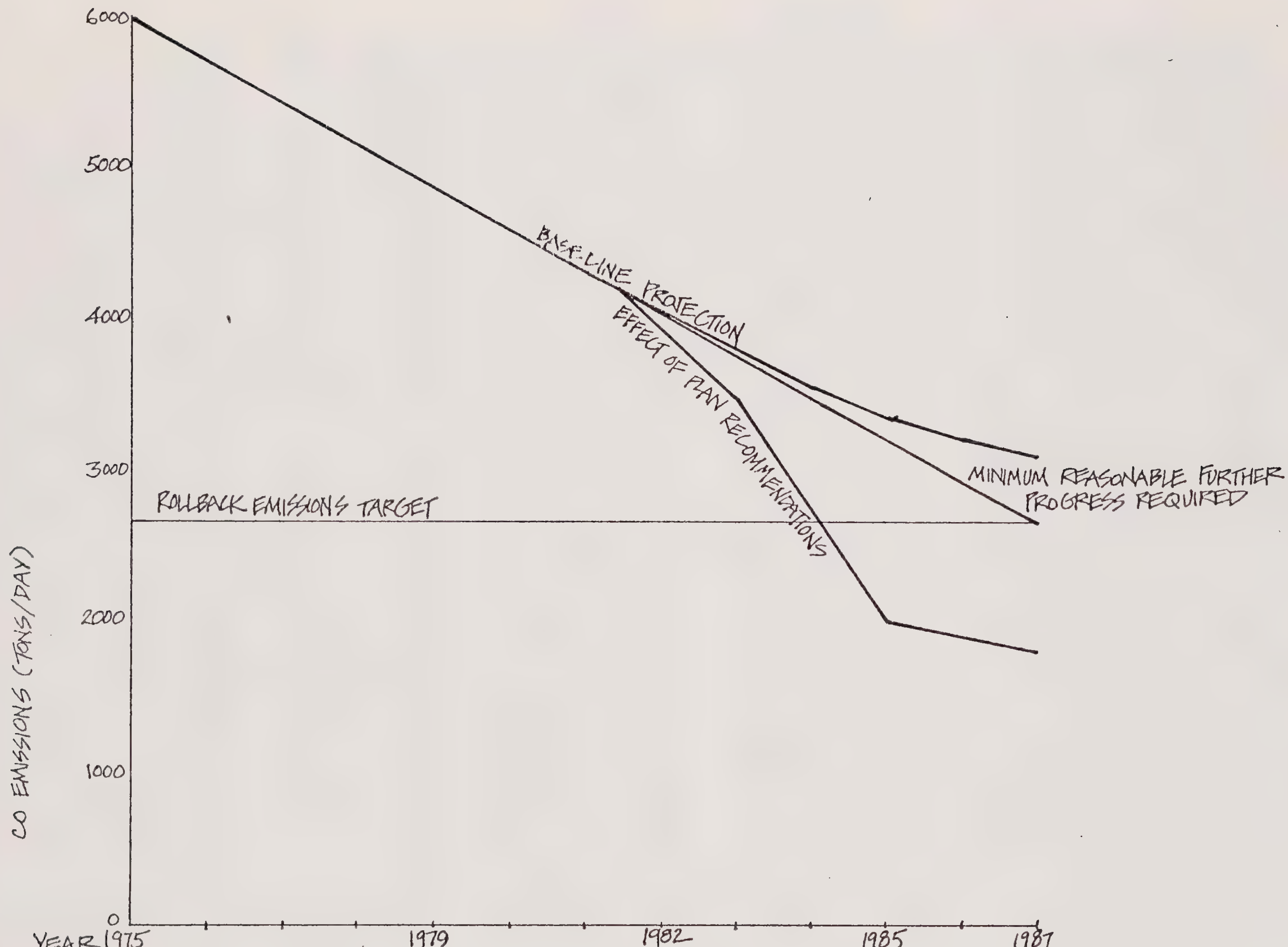


FIGURE 12

PROJECTED REASONABLE FURTHER PROGRESS TOWARD ATTAINMENT OF FEDERAL CARBON MONOXIDE STANDARDS.
(BASED ON LINEAR ROLLBACK AND IMPLEMENTATION OF ALL RECOMMENDED CONTROL PROGRAMS)

The recommendation requires inspection of all light duty automobiles starting in 1982 and the inspection of medium duty vehicles beginning in 1985. The inspections (which would take about five minutes) consists of: visual safety inspections, visual inspection of the emission control systems and exhaust smoke; automatic computer analysis of carbon monoxide and hydrocarbon exhaust gas emissions (could also include oxides of nitrogen, if loaded tests were performed), and an automatic printout of the inspection report comparing the emissions measured to acceptable limits for that particular model. If the vehicle fails the inspection it is required to be repaired by a certified mechanic and then be reinspected. If the vehicle cannot be repaired in order to meet the standard of performance for under a pre-established amount (e.g. $75) then the vehicle owner may be given a waiver for that year. This would not relieve the vehicle owner from future year inspections.

Action 2: Require exhaust emission control devices on existing heavy duty gasoline vehicles.

The regulation of emission levels from heavy duty vehicles (over 6,000 pounds gross vehicle weight) has lagged behind efforts to control light duty vehicle emissions. The slower turnover rate for heavy duty vehicles means they remain in use for a longer time than light duty vehicles. Thus, even with emissions standards for heavy duty vehicles, some control program is needed to minimize emissions from in-use vehicles before they are replace by newer and cleaner vehicles.

The recommendation requires that all heavy duty gasoline (HDG) vehicles manufactured in 1971-1982 be retrofitted with a catalytic converter by 1985. Pre-1971 models are exempt because they require leaded gasoline (leaded gasoline contaminates the catalyst). Post-1982 vehicles are assumed to be equipped with catalysts in order to meet the 1982 emissions standards already adopted by the California Air Resources Board.

Transportation Controls

The following transportation actions encourage use of public transit and other high occupancy vehicle travel modes. These actions were adopted as part of the AQMP and have since been incorporated into the Regional Transportation Plan. Although these were adopted as part of an oxidant strategy, they also have a positive impact on CO emissions.

Action 3: Encourage preferential parking for carpools and vanpools.

Preferential parking could be provided to carpoolers by giving them (1) a discount on parking charges, or (2) a time saving by allocating close-in parking areas. Examples of both types are already in place in the Bay Area. The intent of this measure is to expand these programs. Details of implementation are being developed.

Action 4: Pursue a three-fold transit improvement strategy. (1) MTC, in cooperation with transit operators, will adopt service improvement objectives which can be financed by the existing commitment of resources to transit. Improved capacity, service, and ridership are contemplated. A measure of the improvement expected should be agreed to and committed to in the context of the RTP by October 1, 1978. (2) MTC will continue its

efforts to identify the need for additional services (as it has, for example, in the elderly and hadicapped program and more recently in the Minority Transportation Needs Assessment Project (MTNAP) and to pursue providing additional services as they are justified. A measure of the improvement expected will continue to be developed as these special needs are examined and as the demand for transit services expands generally. (3) During the commute hours all major transit systems in the Bay Area are at capacity. Any substantial increase in ridership will be dependent upon increased Federal or State financial assistance. The amount of ridership increase is directly affected by the amount of increased State and Federal funding. Provision of additional transit capacity represents a positive transportation strategy. Thus the State and Federal governments are encouraged to provide necessary funding support for transit improvements to offset any air-quality deficiencies caused by deleting less desirable transportation control measures. Without this financial support, transit capacity cannot be significantly expanded.

Each transit operator has submitted a capital improvement program which was included in this year's Regional Transportation Improvement Program. On the basis of these improvements, each operator has adopted a ridership target. The decrease in auto travel which corresponds to this is sufficent to produce the expected emissions decrease.

Action 5: Support development of high occupancy vehicle lanes and/or ramp metering on selected freeway segments when justified on an individual project basis.

Some form of preferential treatment (special lanes on the freeways and/or ramp metering with special lanes on ramps) would be given to buses and carpools. MTC and CalTrans are studying a number of congested freeway segments to determine the feasibility of providing preferential treatment.

Action 6: Provide more ride sharing services such as jitneys and vanpools. Objectives need to be developed and monitored to gauge the desirable rate of expansion.

A non-profit corporation funded by CalTrans, the Federal Energy Administration, and MTC, has been set up to expand the RIDES carpool matching program. It has also begun a regionwide vanpool program.

Action 7: Develop more extensive and safe bicycle systems and storage facilities. Objectives need to be developed and monitored to gauge the desirable rate of expansion.

A system of bicycle facilities designed to serve short (2.5 miles or less) work, shopping, or other non-recreational trips is needed. Although these

trips do not constitute a significant portion of travel mileage, they are significant from an emissions standpoint because of the increasing predominance of trip-end emissions (cold start/hot soak) in future years.

MTC will coordinate a regional plan to facilitate this measure, but the actual implementation will be the responsibility of local jurisdictions.

IMPLEMENTATION

Mobile Source Controls - The Role of the California Air Resources Board

Two programs are recommended for implementation by the California Air Resources Board. These control programs are:

- Implementation of an inspection and maintenance program for light and heavy duty vehicles
- Implementation of a heavy duty gasoline exhaust retrofit device for in-use heavy duty gasoline vehicles.

A vehicle inspection and maintenance program for the Bay Area would require State legislation to be implemented. This program would be carried out by the California Air Resources Board and/or the State Department of Consumer Affairs, Bureau of Automotive Repair. The Clean Air Act of 1977 requires that a specific schedule for implementation of a vehicle inspection and maintenance program be included before any time extensions beyond 1982 are allowed for meeting the CO and oxidant standards. It has been assumed that the 1977 Act requirements will be the primary moving force to getting inspection and maintenance implemented in the Bay Area. This program is important for meeting the CO and oxidant standards by 1985-87 and long term maintenance of the standards thereafter.

Implementation of a heavy duty retrofit program would require new State legislation. Such legislation would include the California Air Resources Board to be designated the appropriate implementing agency for the program. To achieve maximum effectiveness from this program, two factors are important:

- The measure would have to be implemented as soon as possible (and no later than 1985). As older vehicles are replaced the need and effectiveness of this control program diminishes.
- The measure would have to be implemented on a Statewide basis. This would prevent vehicles from being registered outside the

Table 12

CARBON MONOXIDE

recommendations

RECOMMENDATIONS	Carbon Monoxide Emission Reductions (tons/day) 1985	2000	RESPONSIBLE AGENCY (or agencies)	SCHEDULE FOR ACTION A - Adoption I - Fully Implemented	TOTAL COST/YEAR OF RECOMMENDED ACTION	FINANCING MECHANISM	LEGAL AUTHORITY

I. Mobile source controls

GENERAL POLICY: REDUCE CARBON MONOXIDE EMISSIONS FROM MOTOR VEHICLES

RECOMMENDATIONS	1985	2000	RESPONSIBLE AGENCY (or agencies)	SCHEDULE FOR ACTION	TOTAL COST/YEAR OF RECOMMENDED ACTION	FINANCING MECHANISM	LEGAL AUTHORITY
Action 1 Implement Statewide inspection/maintenance program for light and heavy duty vehicles.	535	714	CARB and/or Bureau of Automotive Repair	A - 1978 I - 1985	\$1,395,000[a] \$16,892,000[b]	- I/M Program revenues - State General Fund	New Legislation Required
Action 2 Require exhaust control devices on existing heavy duty gasoline vehicles Statewide.	555	-	CARB	A - 1979 I - 1985	\$8,000[a] \$1,534,000[b]	- Private	New Legislation Required

[a] Public agency

[b] Private

ENVIRONMENTAL IMPACTS

Air Quality

- o See "Direct Benefits" column.

Water Quality

- o No impact.

Physical Resources

- o No impact.

Energy Resources

- o Mobile source emissions controls will produce significant energy savings through improved maintenance of engines and emission control systems.

  The inspection and maintenance program and the retrofit program for heavy duty gasoline trucks could save approximately 10,000,000 gallons of gasoline per year, or about 240,000 barrels of oil per year.

INSTITUTIONAL/FINANCIAL IMPACTS

Institutional

- o The governmental structure for implementing mobile source control measures already exists in the California Air Resources Board (CARB) which presently has primary responsibility for controlling vehicular emissions in the State. However, specific institutional arrangements for implementing both the inspection/maintenance programs and the heavy duty gasoline retrofit program will be required since none of them are within the current authority of CARB.

  The California Air Resources Board and/or the Bureau of Automotive Repair (BAR) would likely assume responsibility for the regulation and operation of I/M programs. Local governmental agencies involvement is not anticipated. The CARB has had experience with implementing retrofit programs in the past. It is assumed that implementation of the proposed heavy duty gasoline retrofit program would be assumed by CARB.

  Inspection/maintenance (I/M) programs can be directly administered by the State, or franchised out to private contractors. Data from a pilot I/M program currently being operated in the South Coast Air Basin suggests that the operation of such programs might make disproportionate demands on the administrative resources of the State. Therefore, a private-operated/public-monitored program may be preferable for the Bay Area.

Financial

Direct Public Cost of Implementation

- o See Public Costs (a) in the column headed "Total Cost/Yr of Recommended Action."

Fiscal Effect on Local Government

- o No impact.

ECONOMIC IMPACTS

Production of Goods and Services

- o The implementation of the inspection/maintenance (I/M) measures would add a new line of service for the California automotive service industry. Some services presently exist for identifying defective emission control equipment on cars. They are not, however, universally applicable to all California registered vehicles. I/M programs for light, medium, and heavy duty vehicles would offer a universally applied service program for identification and repair of vehicles with excessive emission caused by maladjusted or defective emission control equipment.

Income and Investment

- o See Private Costs (b) in the column headed "Total Cost/Yr of Recommended Action."

Consumer Expenditures

- o Catalytic converters are estimated to cost about $350.00 per heavy duty vehicle. (Price includes cost of the device and installation charges.) For a light and medium duty vehicle I/M programs an inspection fee of $5-6.00 per vehicle would be required. The average cost of repairs for the catalyst equipped vehicle is about $45.00.

SOCIAL IMPACTS

Housing Supply

- o No impact.

Physical Mobility

- o Because of increased cost of private transportation, the mobility of the limited income segment of the Bay Area population may be impaired. This would be particularly true for those located in other than urban centers.

Health and Safety

- o These control measures would substantially reduce carbon monoxide emissions from motor vehicles. Therefore, substantial health-related benefits may accrue to those segments of the population that experience the heaviest exposure to carbon monoxide concentrations while residing, working or shopping in urban centers.

Sense of Community

- o No impact.

Equity

- o The measures will adversely impact some groups in urban areas more severely than others--particularly those with limited income.

Urban Pattern

- o No impact.

II. Transportation controls

GENERAL POLICY: REDUCE MOTOR VEHICLE EMISSIONS THROUGH TRANSPORTATION ACTIONS TO REDUCE VEHICLE USE

RECOMMENDATIONS	Carbon Monoxide Emission Reductions (tons/day) 1985	2000	RESPONSIBLE AGENCY (or agencies)	SCHEDULE FOR ACTION A - Adoption I - Fully Implemented	TOTAL COST/YEAR OF RECOMMENDED ACTION	FINANCING MECHANISM	LEGAL AUTHORITY
Action 3 Preferential parking for carpools and vanpools.	6	6	Cities, counties, employers, MTC.	A - 1978 I - 1985	$886,000[a]	- Federal Aid highway programs - Local Transportation Development Act funds	- Caltrans enabling legislation - Local planning and traffic control enabling legislation
Action 4 Pursue a three-fold transit improvement strategy. (1) MTC, in cooperation with transit operators, will adopt service improvement objectives which can be financed by the existing commitment of resources to transit. Improved capacity, service, and ridership are contemplated. A measure of the improvement expected should be agreed to and committed to in the context of the RTP by October 1, 1978. (2) MTC will continue its efforts to identify the need for additional services (as it has, for example, in the elderly and handicapped program and more recently in the Minority Transportation Needs Assessment Project (MTNAP) and to pursue providing additional services as they are justified. A measure of the improvement expected will continue to be developed as these special needs are examined and as the demand for transit services expands generally. (3) During the commute hours all major transit systems in the Bay Area are at capacity. Any substantial increase in ridership will be dependent upon increased Federal or State financial assistance. The amount of rider-	48	48	MTC, transit districts (e.g., MUNI, AC, BART)	A - 1978 I - 1985	$3[illegible] million[a]	- Federal Mass Transportation Assistance Programs - Fare revenues - Local Transportation Development Act Funds - State Highway Trust Fund diversions	- Local Transit District Enabling Legislation - Bay Area Rapid Transit District Enabling Legislation - Interagency Memoranda of Understanding

[a] Public agency

[b] Private

ENVIRONMENTAL IMPACTS

Air Quality

- See "Direct Benefits" column.

Water Quality

- No impact.

Physical Resources

- No impact.

Energy

- Gasoline savings from carpooling, the shift to transit, improved traffic flow, and the shift to bicycles.
- Minor increase in transit fuel consumption.

Amenities

- Cleaner air.

INSTITUTIONAL/FINANCIAL IMPACTS

Institutional

- Additional transit service would be provided by the present operators.
- Ride sharing programs would be handled by a recently established non-profit corporation.
- Caltrans would implement high-occupancy vehicle (HCV) lanes and carpool lots.
- Cities and counties would implement bibycle measures. Private employers and businesses would be encouraged to participate.

Financial

- Certain measures, notably the additional transit services, bus/carpool lanes, and bicycle systems, are costly. There is some funding available, but additional funds will be needed. MTC has suggested that the State and Federal governments provice the funding necessary to support the transit improvements.

ECONOMIC IMPACTS

Production of Goods and Services

- New employment in the transit sector.

Consumer Expenditures

- Savings to those commuters utilizing carpools, vanpools or transit.

SOCIAL IMPACTS

Housing Supply

- No impact.

Physical Mobility

- Additional transit service would increase mobility of all transit users.
- Carpool/vanpool measures would increase travel options for most commuters.

Health and Safety

- Reduction in auto accidents with improved peak period flow.
- Possible increase in number, but not rate, of bicycle accidents with increased usage.

Sense of Community

- No impact.

Urban Patterns

- May encourage a more compact land use pattern, with employees living closer to transit lines and/or their jobs.

Equity

- Measures such as additional transit service will particularly benefit low income, handicapped and other persons who depend on this mode of travel.

IMPACTS IDENTIFIED ARE FOR ACTIONS 3, 4, 5, 6, and 7.

RECOMMENDATIONS	Carbon Monoxide Emission Reductions (tons/day) 1985	2000	RESPONSIBLE AGENCY (or agencies)	SCHEDULE FOR ACTION A - Adoption I - Fully Implemented	TOTAL COST/YEAR OF RECOMMENDED ACTION	FINANCING MECHANISM	LEGAL AUTHORITY
ship increase is directly affected by the amount of increased State and Federal funding. Provision of additional transit capacity represents a positive transportation strategy. Thus the State and Federal governments are encouraged to provide necessary funding support for transit improvements to offset any air quality deficiencies caused by deleting less desirable transportation control measures. Without this financial support, transit capacity cannot be significantly expanded.							
Action 5 Support development of high occupancy vehicle lanes and/or ramp metering on selected freeway segments when justified on an individual project basis.	6	6	Caltrans, transit districts, cities and counties.	A - 1979 I - 1985	$7,438,000[a]	- Federal Aid Highway Programs - State Highway Programs funds	- AB 69 (State Transportation Planning Enabling Legislation) - AB 363 (Bay Region Transportation Planning Legislation) - Caltrans Enabling Legislation - Local Planning and Traffic Control Enabling Legislation
Action 6 Provide more ride sharing services such as jitneys and vanpools. Objectives need to be developed and monitored to gauge the desirable rate of expansion.	54	54	Caltrans, employers, MTC	A- Previously adopted I - 1979	$300,000[a]	- Federal Transportation Funding	
Action 7 Develop more extensive and safe bicycle systems and storage facilities. Objectives need to be developed and monitored to gauge the desirable rate of expansion.	65	65	Cities, counties, MTC, Caltrans	A - 1980 I - 1985	$438,000[a]	- Federal Aid Highway Programs - Local Transportation Development Act Funds	- Federal-Aid Highway Legislation - Local Transportation Development Act Legislation

ENVIRONMENTAL IMPACTS	INSTITUTIONAL/FINANCIAL IMPACTS	ECONOMIC IMPACTS	SOCIAL IMPACTS

Bay Area and thus exempt from the control. This would not solve the problem of vehicles registered outside the State. Since many heavy duty vehicles provide inter-state transport, the enforcement aspects of this program could pose some problems.

The heavy duty vehicle retrofit program would be implemented in two stages. The first stage would be to retrofit all 1971-76 model year vehicles by 1980. The second stage would be to require all 1977-82 heavy duty vehicles to be retrofitted by 1985. This program is primarily an attainment measure. Because of the nature of retrofit programs, only short term benefits are gained. Nonetheless, this program is an important part of the comprehensive strategy set forth in the plan for controlling CO emissions.

Transportation Controls - The Role of the Metropolitan Transportation Commission and Others

The Metropolitan Transportation Commission is responsible for preparing the Regional Transportation Plan. The Metropolitan Transportation Commission has adopted the transportation control measures in the AQMP as part of the Regional Transportation Plan. In addition, MTC is coordinating the development of an implementation program for each control measure.

The Metropolitan Transportation Commission would assist in the development of new transit service by applying for and allocating State and Federal funds to transit operators. Actual implementation of the service improvements would be the responsibility of the individual transit districts, and would be programmed to take place over a five year period beginning in 1980.

Implementation of incentives to the use of high occupancy vehicles (e.g., carpools) would be the primary responsibility of the California Department of Transportation. Caltrans would implement the bus and carpool lanes and ramp metering measure relying primarily on federal funds, and would expand its current program of leasing lots underneath freeways and other locations to provide preferential parking for carpools. Carpool matching and data services currently provided by Caltrans will be taken over and expanded by a recently formed non-profit corporation. Finally, to encourage employers to set aside preferential parking for carpools, the Metropolitan Transportation Commission would provide planning assistance and publicity to participating employers.

Implementation of incentives to the use of non-motor vehicle forms of transportation (i.e., bicycling and walking) would primarily be the responsibility of cities and counties, with State and Federal funding assistance.

Bicycle systems are an acknowledged part of the Regional Transportation Plan. Local planners would design facilities, map routes and locations, and estimate costs, while the Metropolitan Transportation Commission would assemble the local plans into a regional plan to aid in securing State and Federal construction grants.

THE DIRECT COSTS OF THE CO PLAN

The direct cost of each of the CO control measures were given in Table 12. They were shown in an annualized form and broken down to capital, operation and maintenance, and administrative/regulatory costs. This section briefly summarizes the costs for the two types of controls being recommended--mobile source emission controls and transportation controls.

Mobile Source Control Costs

The annualized costs for additional mobile source controls is approximately $22 million for the Bay Area. The vehicle inspection and maintenance program would cost about $20 million anually. This cost includes a $5 per vehicle inspection fee and an average repair cost of $45 per vehicle, both paid by the behicle owner. The $5 inspection fee will cover the costs of acquiring land, constructing inspection facilities, equipment, and operation of the facilities. An additional aspect of the program would be that no vehicle owner would be required to spend more than a given amount (e.g., $75) on repairs related to emission control.

The retrofit of heavy-duty gasoline powered trucks with exhaust catalysts is estimated to cost $340 per vehicle, or a total annualized expenditure of $1.5 million for the region. This cost includes a 50,000 mile replacement waranty. The slight increase in operating cost due to the use of unleaded gasoline will be offset by a slight improvement in fuel economy.

Transportation Control Costs

Costs associated with the transportation control recommendations are more complex than the costs for stationary and motor vehicle emission controls. In many cases a redistribution of money within the region is the net result. There are many hidden subsidies given to the use of the private automobile including a variety of public services (judicial system, coroner, fire department, on street parking, city planning, and other services typically financed from property taxes), and local ordinances which require parking to be provided by residential, commercial, and industrial developments. Because these subsidies are not structured on a "user pays" basis, there are existing inequities in the way transportation systems are financed. The current use of bridge tolls to support transit

service improvements could be viewed as a redistribution of subsidies from one transportation system to another. Increased transit services as proposed by this plan for the period to 2000 is estimated to cost $31 million annually, paid for, in substantial part, by additional Federal and State operating assistance. Additional transit service might be needed for maintenance of the standard after 1990.

The cost associated with the carpool incentive programs (preferential) parking, bus/carpool lanes on freeways with ramp metering, and an expanded carpool matching program) total about $9 million annually. The bulk of these costs are due to construction requirements for the bus/carpool lanes and ramp meters.

Finally, the cost of implementing a comprehensive system of bicycle paths and storage facilities is estimates to be approximately one-half million dollars per year. It was assumed that the paths would be striped onto existing roadways where the additional road width required would be accommodated by narrowing existing vehicle lanes.

THE BENEFITS OF A CO PLAN

The benefits to be gained from reducing carbon monoxide emissions would be an improvement in public health. These range from reducing a potential threat to persons with heart disease to reducing interference with normal child development in pregnant women. A reduction in ambient carbon monoxide emissions could also have beneficial effects for some types of plants such as coleus, cabbage, and grapefruit. The effects of short and long-term exposure to carbon monoxide have been the subject of many studies. While conclusive evidence on causal effects cannot be documented, sufficient bodies of evidence clearly indicate the correlation between high levels of carbon monoxide and health effects. These relationships are described below.

General Health Effects of Carbon Monoxide Exposure

With regard to physiologic effects of CO, the most important chemical characteristic of the pollutant is that, like oxygen, it is reversibly bound to the hemoglobin contained in the body's red blood cells and competes with oxygen for binding sites. Where such binding takes place, CO combines with hemoglobin to form carboxyhemoglobin. Because the affinity of hemoglobin for CO is more than 200 times that for oxygen, carbon monoxide can impair the transport of oxygen to body tissues and other vital organs in the body.

• Carbon Monoxide and Associated Carboxyhemoglobin Levels

As a result of several studies, blood carboxyhemoglobin can be estimated in the individual after he or she has been exposed to selected levels of CO for specified durations (see Table 13). These estimates apply only to persons at rest.

TABLE 13

AMBIENT CARBON MONOXIDE (CO) LEVELS AND ASSOCIATED CARBOXYHEMOGLOBIN (COHb) IN PERCENT AND AFTER 1 HR AND 8 HR EXPOSURES

Ambient CO		Percent COHb	
mg/m^3	ppm	1 hr (est)	8 hr (est)
115	100	3.5	11.3
58	50	2.5	7.5
35	30	1.3	4.1
23	20	0.8	2.8
12	10	0.4	1.4

Assumes normal hemoglobin, person at sea level and rest. With exercise, the 1 hour and 8 hour values would be higher. (Estimated)

Source: Benjamin G. Ferris, "Health Effects of Exposure to Low Levels of Regulated Air Pollutants- A Critical Review", Journal of the Air Pollution Control Association, p. 484, 1978, Volume 28, Number 5.

Table 14 summarizes some of the studies that have shown effects at various levels of carboxyhemoglobin. It should be noted that a small amount of carboxyhemoglobin is normal and that if levels are kept below 2.5 percent no effects are apparent.

TABLE 14

LEVELS OF CARBOXYHEMOGLOBIN AND REPORTED EFFECTS

COHb (%)	Effects
0.4	Normal physiologic value for non-smokers
2.5-3	Decreased exercise performance in patients with angina or with intermittent claudication
4-5	Increased symptoms in traffic policemen (headache, lassitude) Increased oxygen debt in non-smokers
5-10	Changes in myocardial metabolism and possible impairment Statistically significant diminution of visual perception, manual dexterity, or ability to learn
10+	Headache and impaired manual coordination Changes in visual evoked response (VER) by EEG

Source: Benjamin G. Ferris, "Health Effects of Exposure to Low Levels of Regulated Air Pollutants-A Critical Review," Journal of the Air Pollution Control Association, p. 485, 1978, Volume 28, Number 5.

- Carbon Monoxide Effects During Exercise

  It has long been known that high blood concentrations of carbon monoxide drastically reduce the body's capacity to perform physical work. Recently, however, attention has been directed to determining the influence of lower concentrations on maximal oxygen update during such physical work. Current research has indicated that maximum capacity and therefore, maximum physical performance, is readily affected even at fairly low CO exposure concentrations.

- Chronic Carbon Monoxide Exposure

  Limited evidence suggests that chronically exposed human beings undergo adaptive changes at CO concentrations higher than those associated with usual community levels. Prolonged exposure, however, may lead to detrimental effects, including growth retardation, cardiac enlargement, and an increased rate of development of cardiovascular diseases.

<u>Specific Health Effects of Carbon Monoxide Exposure</u>

In addition to the various general health effects that result from carbon monoxide exposure, the pollutant can also have some rather specific impacts on the human body. These impacts burden and impede the functions of particular body organs. In the presence of other elements or conditions that are harmful to the body, carbon monoxide could be a significant contributor to the ultimate failure of these bodily subsystems and the death of the individual. These and other specific effects are described in the following sections.

<u>Carbon Monoxide Effects on the Cardiovascular System</u>

The cardiovascular system, particularly the heart, has been found to be susceptible to adverse effects from carbon monoxide at low blood carboxyhemoglobin concentration. The heart requires a continuously available supply of oxygen in order to maintain its ability to function properly. Since carbon monoxide decreases the oxygen-carrying capacity of hemoglobin, presence of the pollutant in the blood stream results in a reduction in oxygen supply available to the heart. Alterations in oxygen content are typically corrected rapidly by an appropriate increase or decrease in coronary blood flow which restores normal oxygen availability to heart tissue. The cardiovascular response to the presence of carbon monoxide then, depends on the ability of the system to dilate and increase blood flow.

Carbon Monoxide and Heart Arterial Disease

Heart disease, characterized by abnormal thickening and hardening of arteries, is the leading cause of death in the United States. Approximately 35% of all deaths are directly attributable to this disease. The clinical characteristics of the disease are particularly pertinent for establishing a causal relationship between it and abnormal thickening and hardening of the coronary arteries. Neither its frequency nor its prevalence in the general human population are known. Very little is known about the specific factors that cause the disease. However, agents that decrease the available oxygen supply, including CO, are primary suspects as precipitating factors in heart attacks.

Environmental exposure to CO and artery-related heart disease may be related in two ways. One of these is that exposure to CO can enhance the development of thickened arteries when associated with other risk factors such as increased cholesterol levels and hypertension. The other is that, in the presence of already severely narrowed arteries, carbon monoxide may be the contributing factor to heart attack.

Carbon Monoxide and Increased Morbidity

Several studies suggest that when people with such heart diseases as Angina Pectoris are exposed to low carbon monoxide concentrations they tend not to be able to exercise as long before developing chest pain, as those with the disease who have not been so exposed. As a result of these investigations and others, it has been suggested that a carboxyhemoglobin concentration as low as 2.5 percent has a deleterious health effect. Since all cigarette smokers and about 10 percent of the nonsmokers in the United States frequently have carboxyhemoglobin concentrations higher than 2.5 percent these studies have important implications. The National Health Survey Examination reported that there were 3,125,000 adults, aged 18 to 79, with definite coronary heart disease and another 2,410,000 who were suspect. If the results of the studies are applicable to this large population at risk then a major health problem exists.

It should be noted that these studies present no evidence that the exposure to carbon monoxide increases the frequency and severity of chest pain or the development of other complications associated with heart disease. Furthermore, they provide little positive or negative evidence that high ambient CO concentrations in a community are associated with either the prevalence of angina pectoris or the natural history of heart disease. They do, however, permit an inference that such relationships exist and provide a basis for further investigation in this important area.

Carbon Monoxide Effects on Behavior

The behavioral effects of low concentrations of carbon monoxide are small and variable. Nevertheless, investigations made to date suggest that carbon monoxide does have an effect on human behavior at blood concentrations even lower than in chronic smokers. The effects found most are those on vigilance tasks frequently cited where a higher incidence of missed observations occurred by individuals under exposure to low CO concentrations than under control conditions. The results of some studies suggest that carbon monoxide may have a slight deleterious effect on driving performance. Low concentrations of carbon monoxide may impair brightness discrimination and there are some hints that various verbal and arithmetic abilities as well as motor coordination are lessened.

Carbon monoxide may modify effects produced by other substances. People drive automobiles under the influence of sedatives, tranquilizers, alcohol, antihistamines, and other drugs. What would be innocuous amounts of such drugs if taken alone may become important determinants of behavior in the presence of low carboxyhemoglobin concentrations.

Carbon Monoxide Effects on the Fetus

It has recently become obvious that the fetus may be extremely susceptible to effects of carbon monoxide carried in maternal blood. Only a few studies have explored the effects of the pollutant on the growth and development of the embryo and fetus, however, those that have evidenced decreased birth weights in newborn babies.

As indicated earlier, CO interferes with the ability of blood and tissue to carry oxygen. This effect operates to compromise oxygen delivery to developing cells. If present briefly at critical periods of embryonic or fetal development or if continued for long periods, these effects may interfere with normal development.

Carbon Monoxide Effects on Plants

Reducing ambient CO concentrations can have some beneficial effects for particular plants although in general, plants are relatively resistant to carbon monoxide. The apparent photosynthetic rate (an indicator of growth rate) of coleus, cabbage, and grapefruit is inhibited at CO concentrations as low as 1-10 parts per million. Carbon monoxide reduction could result in improved production of these plants where they are grown in urban locations.

Section - F

FUTURE WORK AND RESEARCH NEEDS

The plan recommendations for carbon monoxide were developed with a number of unresolved technical issues in mind: the adequacy of existing CO data and analysis techniques, and uncertainties in projected CO emissions. To improve the technical foundation for determining additional controls that may be necessary, several tasks have been identified. These tasks (listed below) may be reevaluated as new information is gathered.

1. MONITORING ANALYSIS

   a) Design a pilot and expanded CO hot spot monitoring programs. A special monitoring program for prototype hot spot areas will be needed to assist in verifying modeling results, and in combination with a linear rollback assumption, can be used to arrive at and control requirements independent of microscale CO model.

   b) Conduct pilot monitoring program. Variables to be monitored will include CO, wind data, traffic counts, speeds, vehicle mixes, and atmospheric stability.

   c) Reduce and compile monitoring data.

   d) Monitor prototype areas. Variables to be monitored will include CO concentrations, wind speed and direction, and traffic. Where possible, wind shear and atmospheric stability will also be monitored.

   e) Reduce and compile monitoring data.

2. REGIONAL SCALE ANALYSIS

   a) Develop prototype CO day for LIRAQ 1. Prototype meteorological fields conducive to buildup of high CO levels must be prepared for regional scale CO analysis.

   b) Run LIRAQ 1. LIRAQ-1 will be run with a 1 km grid size. To cover the Bay Area, three separate, slightly overlapping grids must be used.

   c) Evaluate model performance. LIRAQ results will be viewed and evaluated with respect to existing monitoring data and conditions in the vicinity of monitoring stations. Results should provide estimates of urban background CO levels on the prototype day and may also be used to identify extraordinary CO "hot spot" locations.

3. LOCAL/MICRO-SCALE MODELING ANALYSIS

a) Define prototype and special hot spot situations. Since localized, adverse meteorological conditions can occur from time to time at any location, the space and time distribution of emissions are the crucial variables. Since CO hot spots tend to occur in areas of localized traffic congestion, it is probable that such situations are duplicated in more than one location in the region (e.g., at major freeway interchanges). It is unlikely that sufficient time or resources will be available to fully analyze the problem at each such location; therefore, identification of prototype situations will likely be necessary.

b) Identify/acquire/test appropriate microscale CO model. An inventory and assessment of alternative microscale analysis will be acquired and tested for use in the Bay Area.

c) Develop cooperative analysis arrangements with affected cities/counties. The simulation of future traffic conditions in localized areas requires information and expertise that is best provided by local traffic engineers in the affected jurisdictions. This expertise is particularly crucial for testing alternative traffic management and transportation control alternatives.

d) Identify/develop microscale traffic simulation techniques and assumptions. Since ambient CO levels are largely dependent on microscale emission distributions, microscale traffic simulation techniques and assumptions should be used to properly simulate the effects of alternative transportation controls. Existing regional transportation models are insufficient for this task. (Examples are references 13 and 14.)

e) Develop local traffic projections for prototype hot spots. Once appropriate microscale traffic simulation and CO models are ready for use, baseline projections of local traffic in prototype hot spot areas will be prepared.

f) Seek resolution of uncertainties in motor vehicle CO emission factors. Agreement between EPA and ARB on emission factors appropriate for use in California will be solicited prior to conducting control strategy analyses.

3. LOCAL/MICRO-SCALE MODELING ANALYSIS (cont'd.)

g) Prepare microscale CO emission inventory. Detailed hourly emissions estimates on a street segment by street segment basis for modeling purposes.

h) Model prototype situations. Using the baseline microscale traffic simulations, apply the microscale CO model to determine future CO problems. This exercise should be conducted assuming (1) no additional controls beyond the State and Federal motor vehicle control programs, and (2) assuming extension of the AQMP oxidant strategies to CO.

i) Develop additional control strategies for CO. If the baseline forecasts reveal that CO problems remain after application of previously adopted AQMP controls, additional transportation controls will be developed and evaluated not only for their impacts in the prototype areas, but in adjacent areas as well.

j) Model control strategies. Microscale CO modeling of alternative transportation control strategies will be performed to determine compliance with appropriate ambient CO standards.

4. PLAN SUBMITTAL

a) Evaluation of control measures. Local cities and counties will review a wide range of control measures specifically designed to reduce emissions in their own jurisdiction. Technical support will be provided through ABAG, MTC and BAAQMD.

b) Develop and submit CO plan to approving bodies. Upon completion of the analyses, a draft CO plan will be developed and submitted to the appropriate approving bodies (e.g., cities/Counties, MTC, ABAG General Assembly, ARB).

An approximate schedule for completion of these tasks is summarized in Figure 13, assuming that funding authorized under Section 175 of the 1977 Clean Air Act Amendments will be available by January 1979. The continuing work is envisioned to be conducted in two phases. The first phase will be a pilot analysis in a single problem location (e.g., downtown San Jose). The second phase will be an expansion of the analysis to other prototype hot spots in the region.

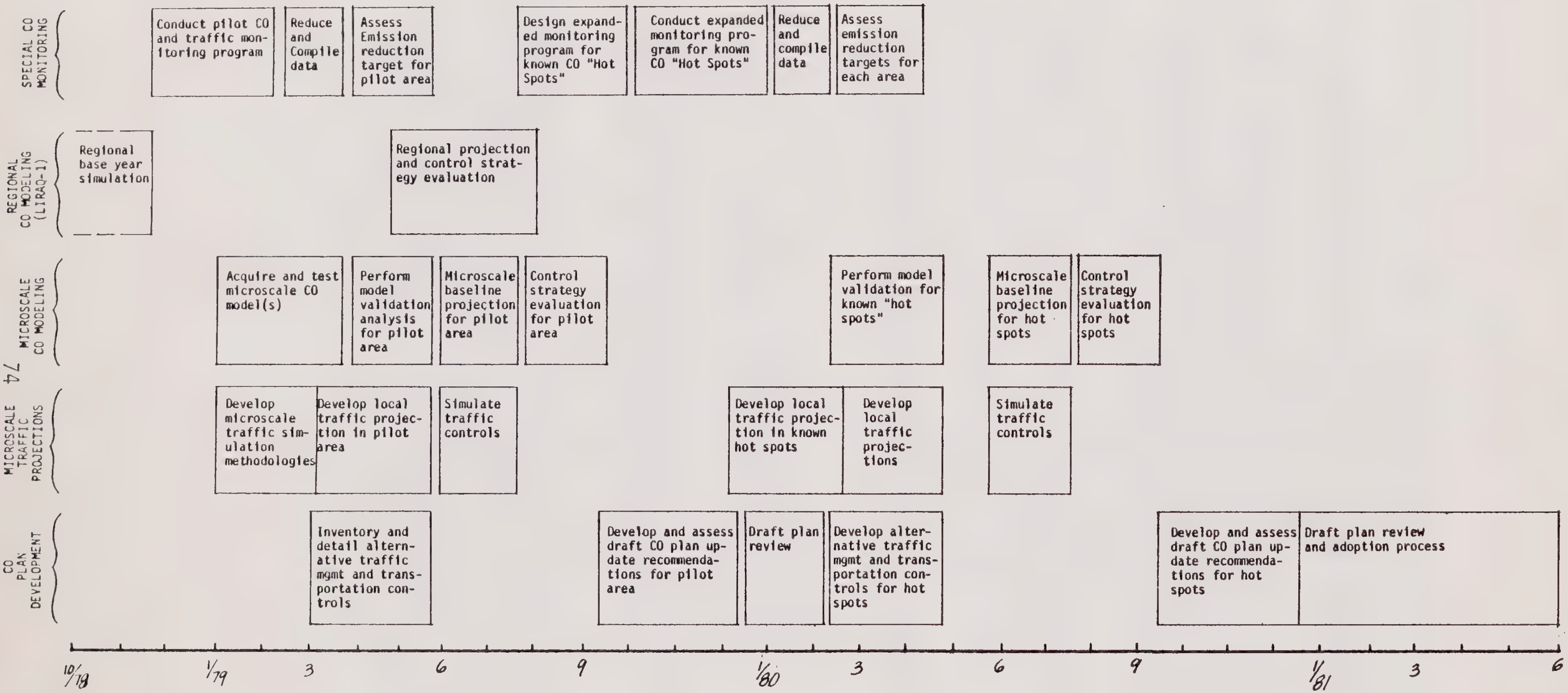


Figure - 15 TENTATIVE SCHEDULE FOR FUTURE WORK ON CARBON MONOXIDE PLAN UPDATE

Section – G

BIBLIOGRAPHY OF TECHNICAL MATERIALS

In the course of developing CO control strategies, the following materials were prepared:

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Throughout the text of the previous sections, numbered references refer to the following 14 reports and studies:

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Reference 11: MacCracken, M.C., and G.D. Sauter, eds., "Development of an Air Pollution Model for the San Francisco Bay Area," final report to the National Science Foundation, Lawrence Livermore Laboratory, UCRL-51920, October 1975.

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Part 2

Total Suspended Particulates

Section – A
INTRODUCTION

The San Francisco Bay Area is designated under the 1977 Clean Air Act as a region where three national ambient air quality standards are not attained. Under the 1977 Clean Air Act, the Association of Bay Area Governments was designated by the California Air Resources Board to prepare (in cooperation with the Bay Area Air Quality Management District and the Metropolitan Transportation Commission) a non-attainment plan for meeting Federal standards for oxidant, carbon monoxide and total suspended particulates. This plan is to be included in revised State Implementation Plan and submitted to the U.S. Environmental Protection Agency.

ABAG's General Assembly adopted an air quality maintenance plan in June 1978 (Reference 1). That plan was designed to reduce hydrocarbon emissions, provided for attainment of the Federal oxidant standard by 1985-87 and maintain meeting the standard thereafter. The AQMP is currently being reviewed by the Air Resources Board, and will form the basis for the oxidant control strategies of the Bay Area's non-attainment plan.

This plan element studies past and future particulate air quality problems in the San Francisco Bay Region. The study includes an approach to ensuring the national ambient air quality standards for total suspended particulate (TSP) are attained and maintained. It will be reviewed by the ABAG Regional Planning Committee on November 8 and December 13. Public comment on the actions will be received at those meetings. The ABAG Executive Board will hold a public discussion on the plan at its November 16 meeting, and a formal public hearing on the plan will be held by the Executive Board, acting for the General Assembly, on December 21. The General Assembly is scheduled to act on this portion of the non-attainment plan at its January 13 meeting.

BACKGROUND

In 1957 four stations began collecting TSP data in the Bay Area for the National Air Sampling Network (NASN). The air monitoring network has been expanded through the years and presently includes 22 TSP sampling sites. The monitoring program will be described in some detail in a later section.

Various ambient air quality standards for suspended particulate have been exceeded in portions of the Bay Region. On September 9, 1975, EPA identified the area as an air quality maintenance area (AQMA) -- an area that has the potential for failing to maintain certain national air quality standards during the 1975-1985 time frame. Particulate matter was one of the designated pollutants for the AQMA. Oxidant and sulfur oxides were also cited (see Reference 2). In a more recent publication (see Reference 3) the EPA has declared that the San Francisco Bay Area Air Basin does not meet the national 24-hour secondary standard for TSP

(150 $\mu g/m^3$), and that Alameda County does not meet the national annual primary standard for TSP (75 $\mu g/m^3$ AGM). Thus the Bay Area Air Quality Management Region, or at least parts of it, are non-attainment areas for TSP. Certain counties -- Marin, Napa, San Mateo, Solano, and Sonoma -- have recently been re-designated (Reference 4) as attainment areas for the secondary standard. Four counties remain non-attainment of either the primary or secondary standard.

To comply with the Clean Air Act the State must submit a plan to attain and maintain the national air quality standards for TSP; primary standards within three years and secondary standards within a reasonable time.

FEDERAL AND CALIFORNIA STANDARDS

The Bay Region is subject to five different particulate standards and one "guideline" (see Reference 5), as shown in Table 1. Through the 21 years of TSP monitoring in the Bay Area, each of these standards has been exceeded somewhere in the air basin. The 24-hour state standard of 100 $\mu g/m^3$ is the most stringent, and is exceeded from time-to-time at several Bay Area Air Quality Monitoring stations. There are a small number of exceedances of the state annual average (60 $\mu g/m^3$ AGM) but almost no violations of the national primary standards (75 $\mu g/m^3$ annual and 260 $\mu g/m^3$ 24-hour). Three factors are mainly responsible for the relatively clean record with respect to the national TSP standards. Two early BAAQMD regulations controlled open burning and the opacity of particulate emissions. The third factor is the general use of natural gas as an industrial and domestic fuel, rather than oil or coal which produce more particulate. Table 2 gives a summary of the district's particulate monitoring experiences with respect to the various standards.

Ambient concentrations of TSP in the Bay Area show a pattern of low values near the coast increasing with distance inland, particularly into dry sheltered valleys. Figure 1 shows an approximate isopleth map for TSP values in the region. The 1975 annual geometric means are shown for the BAAPCD monitoring network. Highest readings occurred in the Santa Clara and Livermore Valleys. Table 2 emphasizes the position of Livermore as the record holder for most TSP exceedances. Because of the high concentrations observed there, the Livermore monitoring station has been the subject of much study. It appears that the site location, near an unpaved commercial lot, combined with intermittent construction at nearby sites, resulted in very localized TSP hot spots. These effects will be discussed in detail in Section B of this plan element.

In addition to the six concentration standards listed in Table 1, there is a State visibility standard. "Visibility reducing particles" should not be present in sufficient amount to reduce the prevailing visibility to less than 10 miles when the relative humidity is less than 70%. The BAAQMD routinely compiles visibility and humidity data from five major airports where hourly readings are taken. In 1976 there were 154 days of poor visibility (as defined) in San Jose but only 72 in Fairfield. For 1977 the

Table 1. Ambient Air Quality Standards for Suspended Particulates

Averaging Time	California Std.[1]	National Standards[2]	
		primary[3]	secondary[4]
24-hour[5]	100 $\mu g/m^3$	260 $\mu g/m^3$	150 $\mu g/m^3$
1-year[6]	60 $\mu g/m^3$	75 $\mu g/m^3$	60 $\mu g/m^3$

(The high volume sampler[7] is the accepted test method.)

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[1]California standards should not be equalled or exceeded at any time.

[2]National standards, other than annual averages, are not to be exceeded more than once per year.

[3]National primary standards are the levels of air quality necessary, with an adequate margin of safety, to protect the public health. Each state must attain the primary standards no later than three years after the implementation plan is approved by the EPA.

[4]National secondary standards are the levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant. Each state must attain the secondary standards within a "reasonable time" after the implementation plan is approved by the EPA.

[5]The 24-hour average is obtained by weighing the total particulate catch on a filter from a continuous 24-hour sampling period.

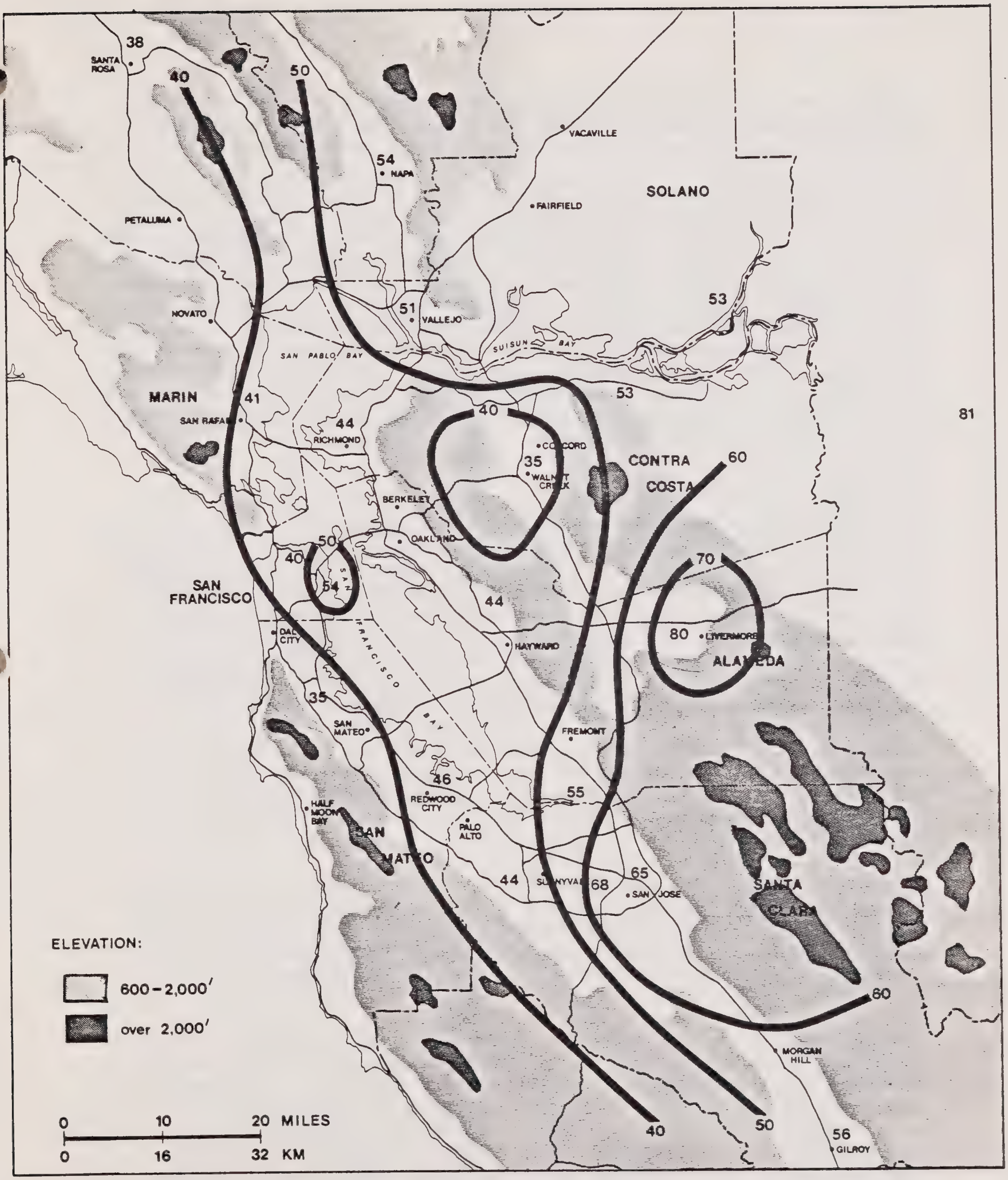
[6]The annual geometric mean (AGM) is the product of all the 24-hour readings, divided by the number of readings; or equivalently, the antilog of the (arithmetic) average logarithm of the individual readings.

[7]EPA method specified in Federal Register, Volume 36, Number 84, Friday, April 30, 1971, p 81, or 40 CFR 50.6, 50.7 and Appendix B.

Table 2 Summary of TSP Monitoring Data in the Bay Area, 1972 - 1978

Averaging Time	Standard (μg/m³)		- Year - 1972	1973	1974	1975	1976	1977	1978**
24 hr	100 state	number of stations with ≥ 1 excesses	6	15	16	15+	19+	15+	7+
		% of sampling days over std., highest station	17(L)*	23(P)	23(L)	23(L)	41(L)	19(L)	16(L)
24 hr	150 national secondary	number of stations with >1 excess	1	7	10	12	18	8	4
		% of sampling days over std., highest station	1(L)	3(L)	5(L)	13(L)	11(L)	2(L)	1(B)
24 hr	260 national primary	number of stations with >1 excess	0	0	2	0	0	0	0
		% of sampling days over std., highest station	--	--	1(v)	--	2(c)	--	--
annual (AGM)	60 state std. and national sec. "guideline"	number of stations over standard	1	3	1	2	12	3	1
		highest station value (station)	67(L)	66(L)	71(L)	80(L)	85(L)	68(L)	62(L)
annual (AGM)	75 national primary	number of station over standard	0	0	0	1	1	0	0
		highest station value (station)	--	--	--	80(L)	85(L)	--	--
Total*** number of stations in network			15	17	18	19	19	20	18

*Station identifier: (L) = Livermore, (c) = Concord, (v) = Vallejo.
**Partial year data, January through June, 1978.
***Total number of sampling sites, including BAAPCD stations and NASN sites, with sampling at one site for entire calendar year.



1975 Annual Geometric Means of Total Suspended Particulate in $\mu g/m^3$ (by hi-volume method with fiberglass filters). Federal primary standard is 75 $\mu g/m^3$. State standard is 60 $\mu g/m^3$.

Figure 1

results were 135 and 34 days, respectively. The State visibility standard is exceeded frequently at all five study sites. Visibility data (days over standard) are compiled in Table 3 for recent years.

BAY AREA MONITORING PROGRAM

The ambient air monitoring system in the Bay Area includes BAAQMD stations and NASN stations. In addition to the permanent network, there are scattered industrial monitors, airport monitors, private, academic and government research projects. With one important exception, only the permanent network results will be considered here. The outside data are difficult to obtain, usually of short-term or intermittent coverage, and may include non-standard sampling equipment or procedures. Outside data are cited for one purpose in this report, to show background TSP levels in the sense of 40 CFR §51.13(c); because no comparable data are available from the permanent urban air monitoring network.

Monitoring Sites and Procedures

Even the permanent network, unfortunately, is not exactly permanent. The system started with four NASN sites in 1957, expanded through the years to 25 stations in 1978, but will drop to 23 stations at the end of 1978. This last decrease is the result of closing two NASN sites (Oakland and San Francisco) in mid-1978. In addition to the variation in number of stations, there have been some changes in location necessitated by space requirements, lease arrangements, and other factors. Since TSP concentration patterns are very localized, a change in the station location can have substantial effects on the monitoring record.

Table 4 is a list of TSP monitoring sites in the Bay Area for the period of 1972-1978. Though the network has changed slightly through the years, the problem stations -- Livermore, San Jose, and Fremont -- where most excesses occur, have been operating in the same locations through the study period of 1973-77.

Monitoring Procedures. TSP concentrations are calculated by weighing the filter catch from a 24-hour run of a hi-volume sampler. The method and apparatus have been in routine use for years, though shortcomings have been recognized and, in some cases, minimized. Flow rate, siting, filter composition, and relevance of the TSP value to health have all been questioned.

BAAQMD samplers are run from 3 p.m. to 3 p.m. every third day or every sixth day. Readings for submittal to ARB and EPA are collected on glass filters and synchronized with the EPA six-day schedule. Some samples -- alternate days at some stations, or duplicates at Pittsburg and San Jose -- are collected on cellulose (paper) filters for comparison purposes and possible silicate analysis. (As noted in Reference 6, comparisons over a 4-year period indicate that glass fiber results average 7.5% higher than cellulose fiber results.) BAAQMD hi-vols are fitted with constant flow controllers, to maintain a flowrate of about 30 cfm throughout the 24-hour sampling period. The pressure drop across the

Table 3 Days per Year When Visibility Was Less than State Standard (10 miles with relative humidity less than 70%)

Airport	Year 1972	1973	1974	1975	1976	1977	1978[1]
San Francisco[2]	138	108	119	129	172	123	(30)
Oakland	92	57	(75)	77	96	95	(30)
San Jose	145	109	144	128	154	135	(38)
Travis[3] (Fairfield)	(15)	27	57	38	72	34	(8)

[1] Data through June, 1978.
[2] San Franicsco International Airport, about 5 miles south of the City of San Francisco.
[3] Travis Air Force Base.
( ) Parentheses indicate incomplete data base. True annual value would be greater than shown.

Table 4. Bay Area TSP Monitoring Sites -- Permanent Network

BAAPCD Sites Street Address	City	(1) Location	(2) Dom. Infl.	(3) Traffic Type	(4) Non-Compl.
939 Ellis Street	San Francisco	CC	COM	COM	R
900 23rd St (Potrero)	San Francisco	CC	IND	FWY	
4984 Cabrillo Hwy.	Pacifica	SU	REC	ART	L
534 Fourth Street	San Rafael	CC	COM	COM	
1144 13th Street	Richmond	SU	IND	ART	
583 W. Tenth Street	Pittsburg	SU	IND	COM	
991 Treat Blvd.	Concord	SU	RES	ART	L
40733 Chapel Way	Fremont	SU	COM	COM	
2131 Railroad Ave.	Livermore	CC	COM	COM	
120 N. Fourth St.	San Jose	CC	COM	COM	
7671 Monterey St.	Gilroy	CC	COM	COM	
251 Murphy Ave.	Sunnyvale	SU	COM	COM	
12333 S. Saratoga Rd.	Saratoga	SU	COM	ART	
897 Barron Avenue	Redwood City	SU	COM	COM	
1229 Burlingame Ave.	Burlingame	CC	COM	COM	
Millbrae Ave & Rt.101	Millbrae	SU	VEH	FWY	L
437 Humboldt St.	Santa Rosa	CC	COM	COM	
2552 Jefferson St.	Napa	CC	COM	ART	
304 Tuolumne St.	Vallejo	CC	COM	ART	
2220 Moore Park Ave.	San Jose	CC	VEH	ART	
1111 Jackson	Oakland	CC	COM	COM	H
NASN Sites					
120B N. Fourth St.	San Jose	CC	COM	COM	
499 Fifth Street	Oakland	CC	COM	FWY	*
101 Grove Street	San Francisco	CC	COM	COM	*
2151 Berkeley Way	Berkeley	SU	COM	ART	*

(1) Location: CC = center city, SU = suburban, RU = rural.

(2) Dominating Influence: COM = commercial, RES = residential IND = industrial, VEH = vehicular, NU = near urban, AGR = agricultural, REC = recreational area (seacoast in this case).

(3) Traffic Type: COM = commercial, RES = residential IND = industrial, FWY = freeway, ART = arterial.

(4) Non-complying factors, based on proposed EPA guidelines -- Federal Register, Vol. 43, No. 152 -- Monday, August 7, 1978.
H = too high (>15 meters above grade).
R = restricted by wall or barrier.
* = unknown.
L = too low (<2 meters).

filter is used to vary the voltage to the blower motor to keep the airflow nearly constant, whether the filter is clean or loaded.

NASN samplers are run midnight to midnight on a national sampling schedule with readings every sixth day (every twelfth day before 1976). Glass fiber filters are used and flow rate is the arithmetic average of a pre-sample reading and a post-sample reading.

Limitations of the Monitoring Data Particle Size. The fundamental limitation of the TSP data is its relevance to the protection of public health and welfare. It has been known for years that the smallest particles, say 0.1 to 1.0 μ, present the greatest threat to health, because these are carried deep into the lungs. The TSP measurement, by contrast, is strongly influenced by the concentration of large particles, though the sampler housing design may exclude those over 100 μ.

Friedlander (see Reference 7), for example, found that:

> Total weight is an inadequate measure of particulate pollution and its effects. Particles in the 0.1 to 1 μ range generally have a much greater impact on public health, visibility, and cloud nucleation...

and further:

> It is quite possible that total particulate mass may be decreasing...while air quality declines because the mass of material in the submicron range increases. Just such a development may have been taking place in Los Angeles....

Friedlander points out that the most common particulate control methods, mechanical and electrostatic, seem to have a minimum efficiency in the 0.1 to 1 μ range. Thus large reductions in total mass emissions may still leave dangerous amounts of small particles in the effluent and the ambient air.

The EPA has invested considerable effort in recent years to develop a fine particle air quality standard, with a supporting sampling method. The so-called dichotomous samplers are past the development stage and commercial availability is expected soon. But the overall transition to a fine particle approach to air quality is still 18 months to two years away, according to EPA sources.

It seems clear that a fine particle standard will be adopted in the future, with new sampling devices and techniques. Most importantly, this will require a new review of health effects, sources, attainment status, and control programs to meet the new standards. Meanwhile, the inertia of years of hi-vol data requires preparation of a plan to attain the present TSP standards.

Chemical Composition. A second limitation of TSP data is the lack of composition information. The routine TSP sampling procedure provides no clue to the sources contributing to a given receptor, nor the possible health effects of the particulate mix. Primary and secondary, man-made and natural, harmful and benign components may be present in any proportion. Sulfates, for example, have been recognized as especially harmful and irritating to humans. The State of California has adopted sulfate and lead standards to control two possible components of the particulate burden. Various studies have been made to elucidate at least the average composition of urban dusts. Results are mixed, with some research indicating substantial amounts (26 to 42%) (see Reference 8) of natural components such as soil and sea salt. Grosjean (see Reference 9) has studied secondary organic aerosols, resulting from photochemical processes. Novakov's group at the Lawrence Berkeley Laboratory has studied primary carbonaceous matter (soot) from stationary and mobile sources, elemental composition of TSP, and SO_2/sulfate conversion (see Reference 10). Another group at U.C. Davis has been very active in size and elemental analysis of particulate matter (see Reference 11).

A great deal of information is now available on the composition of particulate matter from selected sites, but the knowledge is generally not transferable over time or over space, except as order of magnitude estimates. A study of limited composition data from Bay Area Stations has been published (see Reference 12) and the results will be considered in Section B of this report.

Siting. In the past, ambient air monitoring stations were set up on the basis of some a priori judgments of air quality problems and on the availability of space and labor. The Air Quality Management District office building, other public buildings, and available rentals often determined the sampling sites. Since TSP measurements are so sensitive to large particles, and since the presence of large particles is so dependent on local conditions, the extreme values in a TSP record are, to a great extent, the result of local fugitive dust. One experimental BAAQMD monitor (Pacifica) is near the seacoast, with no industrial sources in the vicinity and little anthropogenic contribution. The natural local sources, however, produce the highest TSP readings in the region. At inland sites, an unpaved parking lot, construction, or demolition near a monitoring site will influence TSP readings much more than the average small particle content which is actually more harmful. Livermore, for example recorded an extreme value of 601 $\mu g/m^3$ on January 30, 1976, because of construction in an adjacent area. EPA has recently proposed guidelines (see Reference 13) for the siting of air quality monitors, including particulate, which attempt to minimize -- or at least standardize -- siting effects. Such guidelines are desirable and will be beneficial if the responsible agencies can support the cost of implementation. Still more beneficial, however, would be the changeover to a fine particle standard, which would nearly eliminate the (large size) fugitive dust interference/siting problem.

Flow Rate. The flow volume measurement is probably the chief source of error in hi-vol data, though filter handling and conditioning also introduce some uncertainty. Several approaches to flow-measurement have been tried, including constant flow, pre-/post-sample measurement, continuous recordings, and limiting orifice. None have proven completely satisfactory; side-by-side samples give results which differ by several percent.

Filter Composition. Cellulose and glass fiber filters are the most common collecting media, though more exotic materials may be required for certain analytical techniques. Cellulose was used in early monitoring efforts and has been retained for certain kinds of chemical analysis, especially silicate. Glass fiber filters have been standard in recent years, probably because the fiber does not absorb water and is thus less sensitive to humidity and (variations in) sample conditioning. Some claim that the basic nature of glass, and/or the binders used in manufacture, interact with acid gases to produce artefact TSP.

Section-B

PROBLEMS, CAUSES AND FUTURE PROSPECTS

This section describes total suspended particulate problems, existing control programs and future particulate problems.

PROBLEM DEFINITION

The latest designations show Alameda County as a non-attainment area for the total suspended particulate (TSP) primary standard (75 $\mu g/m^3$ AGM). Contra Costa, Santa Clara, and San Francisco counties are non-attainment areas with respect to the 24-hr secondary standard of 150 $\mu g/m^3$. A compilation of TSP monitoring values >150 $\mu g/m^3$ is included as Appendix A of this plan element. Data are listed by individual station for 1975, 1976, and 1977, with available 1978 results.

Historical Air Quality Trends

BAAQMD meteorologists analyzed eight years of TSP monitoring data (1969-1976) and published a report (see Reference 6) in which they concluded:

a. A slight downward trend in this 8-year period was overshadowed by weather-induced fluctuations.

b. Anomalies at individual stations are frequently associated with nearby construction activities.

c. The three excesses of the Federal 75 $\mu g/m^3$ AGM standard were all associated with highway construction.

Table 2 summarizes TSP data available for the eight most recent years, with 1978 data incomplete as of October 1978. During these years the national 75 $\mu g/m^3$ AGM standard was exceeded only at Livermore in 1975 and 1976. The results were borderline with AGMs of 74 in 1972 and 1974 but lower in 1973, 1977 and, so far, in 1978.

Meteorological Effects

1976 was clearly the worst year for TSP, with two related meteorological factors contributing. First, the extreme drought conditions that plagued the northwestern states in 1976 and 1977 produced greater quantities of fugitive dust. Second, the stagnant weather conditions associated with the drought did not provide the air ventilation that normally disperses pollutants. November and December of 1976 were especially bad for TSP. In fact 71% of the 1976 readings 150 $\mu g/m^3$ were recorded in the last two months of the year (see Reference 14). Mean wind speeds were less than half of normal and were the lowest in 15 years of record. November

and December of 1976 produced 34 days with stability factors* greater than 12 F^0. Subsidence and radiation inversions combined to produce very restrictive surface-based stability. Of the 16 sampling days during the two-month period, 13 were days with temperature inversions, producing a flurry of high TSP measurements. For the normally rainy month of December, there were only two days with measurable precipitation. January 1976 also produced several excesses of the secondary standard. And, from the limited Bay Area data for remote sites, a value of 101 $\mu g/m^3$ was recorded (see Reference 15) on January 31 in the Montezuma Hills, several miles from any industrial or vehicular sources.

December of 1975 was similar to December of 1976 with respect to dry, stagnant conditions, but not quite so extreme in the stabilities observed. December 1975 had only 10% of normal presipitation and had 13 days with stability factors >12F^0, compared to 23 in 1976. Out of 10 sampling days in December 1975, Livermore posted 9 TSP values above 100 $\mu g/m^3$. Again fugitive dust from nearby highway construction combined with restrictive meteorology to produce high local concentrations.

The drought years had an extra disadvantage, in that source operators who wanted to control fugitive dust (by watering) were unable to obtain water supplies for that purpose.

Emission Inventory

The BAAQMD Source Inventory for particulate matter is shown in Table 5 for the years 1972 through 1978, with 1975 as the baseline calculation year. The table is a summary form, showing only seven source categories. More detailed breakdowns are available (see Reference 16), but this version provides sufficient detail for the present purposes.

The source inventory totals for the period shown have decreased about 15%, mainly in the burning of materials and motor vehicle categories, but future projections show an increase to 210 tons/day for 1985 and 250 tons/day for 2000. The particulate inventory totals used in the Air Quality Management Plan (see Reference 4) differ slightly from the BAAQMD inventory because of a different calculation of mobile source emissions. The AQMP particulate totals are 169, 192 and 225 tons/day for 1975, 1985 and 2000 respectively. The major increases for future years come from combustion of fuels and aircraft emissions. These increases seem largely unavoidable, with fuel switching from gas to oil, and inevitable growth of air travel and transport.

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* Stability factor, as calculated at the BAAQMD, is temperature (^{0}) at 2500 feet minus surface temperature, from Oakland, Vallejo or San Jose. Higher (positive) values indicate stronger low-level inversions and decreased vertical mixing.

Table 5. Source Inventory (Summary) for Particulate Matter (1975 base-year)

Tabled values: particulate emissions, (tons/day) annual average

Source Category	- Year - 1972	1973	1974	1975	1976	1977	1978
Petroleum refining	6	6	3	3	3	3	4
Chemical	8	8	5	5	5	5	5
Other industrial/commercial	80	77	76	75	76	77	78
Combustion of fuels	16	17	16	16	23	21	24
Burning materials	30	19	13	13	13	13	13
Off-highway mobile sources	5	5	5	5	5	6	6
Aircraft	10	10	9	9	8	9	9
Motor vehicles	53	54	55	49	48	47	47
Total	208	196	182	175	181	181	186

Major improvements in the particulate inventory occurred between 1958 and 1970, as BAAQMD regulations controlled agricultural burning, opacity and incineration. The 1958 total of 420 tons/day was reduced by 50% to 210 tons/day by 1970. The most striking reductions were 70 tons/day in "other industrial/commercial" between 1960 and 1961, and 46 tons/day in "burning of materials" between 1969 and 1970.

The major weakness in source inventory considerations, is the limited data on fugitive dust. As mentioned previously, it is fugitive dust that is largely responsible for TSP values, especially the extreme values. The most striking example was a group of readings taken on December 20/21 in 1977 when the Bakersfield dust storm reached Bay Area monitors. Eleven stations produced readings above 1000 $\mu g/m^3$ with a high of 3300! (This episode is excluded from compliance considerations, as allowed by SIP regulations.) More common are local dust storms, often from construction or demolition sites, which affect only one monitor. None of those are included in source inventory calculations.

There is some potential now to develop at least an annual average inventory for some fugitive dust sources. An EPA publication (see Reference 17) provides a summary of some methods to estimate particulate emissions from unpaved roads, agricultural fields, construction sites, storage piles, etc. An attempt will be made to incorporate these sources into the existing inventory, but there are several problems to consider: the limited data bases, geographical transfer effects, and new data required (silt content of soil, Thornthwaite index, rainfall days, crop type acreage, etc.) This will clearly be an extensive project, but useful for long-term modeling with respect to the secondary standard. For attainment of the primary standard, we will have to rely on the monitoring record and qualitative judgment of local source variations.

The present inventory may provide clues for control of chronic contributors to the TSP burden, but the Bay Area has already controlled these regular stationary sources over the past two decades. In fact, if one sees a steady plume in the Bay Area today, it is almost certainly one of the following three:

a) agricultural burning by permit on a "burn day" -- an announced day with meteorology to disperse pollutants,

b) a white steam plume, with water vapor condensing in cooler atmospheric air, or

c) an accident -- a structural fire or industrial breakdown.

Several companies are carried on the 1975 Source Inventory (see Reference 16) at particulate levels that could total more than 100 tons/year. These are compiled in Table 6. It is noteworthy that none of these major sources is located near the Livermore monitor.

Table 6. Companies with Particulate Emissions >100 tons/year

Source: BAAPCD Source Inventory, 1975

Company	Location	tons/day	tons/year
C & H Sugar	Crockett	.8	292
Chevron Chemical	Richmond	.3	110
Collier Carbon	Rodeo	.6	219
Exxon	Benecia	.8	292
Fibreboard	Antioch	1.3	475
Kaiser Cement	Permanente	.5	183
Owens Corning	Santa Clara	.7	256
Owens Illinois	Oakland	.4	146
Pacific Gas & Electric	Antioch	1.0	365
P.G. & E.	Hunters Pt.(S.F.)	.4	146
P.G. & E.	Pittsburg	2.3	840
P.G. & E.	Potrero (S.F.)	.4	146
Lion Oil*	Martinez	1.7	621
Shell Oil	Martinez	.5	183
Standard Oil of Cal.	Richmond	2.1	767
Union Oil of Cal.	Rodeo	.8	292
Total		14.6	5329

*was listed as Phillips Petroleum in 1975.

In general, BAAQMD Regulation 2, §6112.2 prohibits any single source operation from emitting more than 40 lb/hr of particulate matter. (A source may emit more than 40 lb/hr only if the p.m. loading is below certain specified low levels, §6112.3.) The 40 lb/hr is equivalent to about 0.5 tons/day or 175 tons/year. Most of the companies in Table 6 have several separate source operations contributing to the emission totals shown.

Compared to the 1975 source inventory total (Table 5) of 175 tons/day, the major sources in Table 6 sum to only 14.6 tons/day or 8.3% of the inventory. Much of this is from combustion of fuels.

Motor vehicles and industrial/commercial categories contain the largest entries in the particulate inventory. Mobile source emissions are not under local jurisdiction, but depend rather on State and Federal regulations. It is estimated that particulate emissions from motor vehicles would be reduced by about 8 tons/day by 1985 (see Reference 18), primarily due to lower exhaust emissions from catalyst vehicles. Tire dust presumably is a function of vehicle miles travelled (VMT), and not much subject to control.

Stationary source contributions can be examined in more detail in Table 7, where 1975 and 1985 estimates are presented for comparison. Included in Table 7 are the 1975 distribution percentages for major point sources and area sources. "Area sources" includes small point sources whose emissions were not calculated on an individual basis. The reader may note from Table 7 that only three source categories have emissions more than 10 tons/day. These are No. 15 Stone, Sand, Gravel, No. 18 Farming, and No. 22 Other Industrial/Commercial. Category No. 73 Accidential Structural Fires is close with an estimate of 9.37 tons/day. All four large categories are predominantly area sources that are difficult to control. (No. 73 is by definition impossible to control.)

There is always some potential for emission reductions via more stringent controls on known stationary sources. For example the basic grain loading limit could be reduced from the present 0.15 gr/SDCF level. Or the 40 lb/hr maximum emission rate could be reduced, or the maximum allowable opacity could be reduced from the present 20% (Ringelmann 1). These measures will be considered in Section III, but the inventory demonstrates that the greatest contributors to the particulate problem are the area sources with fugitive dust type emissions.

Chemical Characterization of TSP Data

Suspended particulate matter in the air comes from many sources and thus has a complex and varying composition. Some comes from natural sources -- the sea, the land, volcanos, geysers -- but probably a greater portion is a result of man's activities, especially handling of materials, combustion, agriculture, and manufacturing.

Table 7. Details of 1978 and 1985 Stationary Source Inventory (Particulate)

No.**	Category	Annual Average Tons/day 1975	Annual Average Tons/day 1985	Major Point %	Area* %
PETROLEUM REFINING					
1	Refining Processes	1.41	2.66	100	0
2	Other Processes	.80	1.47	100	0
3	Upsets, Breakdowns, Flares	.30	.25	100	0
CHEMICAL					
6	Sulfur	.28	.22	100	0
7	Sulfuric Acid	.06	.09	100	0
9	Other Chemical	4.53	5.16	13	87
OTHER INDUSTRIAL/COMMERCIAL					
10	Pulp and Paper	.82	.95	100	0
11	Metallurgical	2.92	3.38	3	97
12	Asphaltic Concrete	.79	.73	100	0
13	Concrete Batching	1.11	1.27	0	100
14	Glass Mfg.	1.63	1.86	100	0
15	Stone, Sand, Gravel	15.16	17.30	0	100
16	Sandblasting	5.93	6.88	0	100
17	Other Mineral	3.74	4.26		
18	Farming	10.53	10.30	0	100
19	Food/Agric. Processing	5.88	6.70	14	86
20	Paint Spray Mist	5.74	6.64	0	100
21	Wood Products Mfg.	4.69	5.34	0	100
22	Other Industrial/Comm.	16.35	18.60	2	98
COMBUSTION OF FUELS					
42	Domestic	4.38	4.97	0	100
43	Comm./Institutional-Gas	1.27	1.73	0	100
44	-Oil	--	--		
45	Oil Ref.Ext.Comb.-Natural Gas	1.42	1.71	100	0
46	-Ref.Make Gas	1.36	1.90	100	0
47	-Fuel Oil	.89	4.29	100	0
48	-Coke	--	--		
49	Power Plants-Gas Boilers	1.86	--	100	0
50	-Oil	2.77	14.50	100	0
51	-Coal	--	1.08	100	0
52	-Gas Turbines	--	--		
53	-Oil	--	1.44	100	0
54-66	Other Combustion	2.40	4.45	varies by category	
BURNING OF MATERIALS					
67	Residential Incineration	1.06	1.21	0	100
68	Comm./Inst. Incin.	.58	.66	0	100
69	Industrial Incin.	.08	.09	0	100
70	Agric. Debris Burning	1.14	1.14	0	100
71	Range/Forest Burning	.37	.37	0	100
72	Accidential Wild Fires	.28	.27	0	100
73	Accidential Structural Fires	9.37	10.7	0	100

*"Area" sources include small [>0.1 ton/day] point sources.
**Category (numbers) not appearing in table have no particulate emissions.

AQMP Tech Memo 24 (see Reference 12) included a study of the chemical composition of the TSP catch at three Bay Area problem stations -- Livermore, San Jose and Fremont -- based on 1975 annual averages. Only partial chemical analysis was available, as the data were not originally intended as a complete analytical scheme. But the limited results are informative, and a composition summary table for Livermore is shown here as Table 8. These results were obtained by a series of mass balances using known or estimated composition of various sources and the partially known composition of the TSP catch.

The proposed source origin scheme could account for about 85 % of the measured particulate catch at Livermore. Soil particles made up about 35% of the catch, soot and organics about 24%, and sea salt up to 10%, tire dust 7%, secondary nitrates and sulfates 7% and auto exhaust 2%. The auto exhaust value appeared low and the tire dust high compared to limited data from Southern California (see Reference 19). The sources mentioned above sum to 85% of the filter catch; the analyses provided no clues to the remaining 15%.

The soil-like contribution of 35% again implicates fugitive dust as the main component in the Livermore TSP catch. The organic component (24%) is probably about half primary soot emitted from combustion processes. This assumption is based on preliminary data from LBL Atmospheric Aerosol research projects. A substantial part may be secondary photochemical reaction products, formed in the atmosphere from gaseous precursors (hydrocarbons and oxides of nitrogen). This would be most important on summer oxidant days, but less important on winter days when most TSP excesses are observed.

Though the analysis provides some explanation of the particulate problem, it does not give us detailed clues to efficient control measures. Three key weaknesses can be mentioned.

a) Since the TSP problem is so variable over space and time, one needs detailed source and filter catch compositions for a single day (an excess day) to pinpoint the sources contributing to the excess. The annual average data cited above provide only general guidance.

b) The biggest category, soil-like particles, could be a result of wind suspension, or could have been stirred up by man's activities (vehicles, construction, quarrying, etc.).

c) The soot and organics category may be amenable to some control, but it is not yet clear if combustion products or organic gases, or both, are responsible. Control measures would be very different for the two cases.

A comprehensive program to collect particle size and composition data has been proposed (see Reference 12) -- but not yet implemented -- to identify

Table 8. Various Source Contributions to Livermore Particulate Catch
Concentrations in $\mu g/m^3$ of ambient air

1975 Annual Average

	Soot & Organic	Soil	Sea Salt	Second. Nitrate	Second. Sulfate	Auto Exhaust	Tire Dust	TOTAL	DATA
Organic	16.33*	1.37				.61	4.19	22.5	22.5 ± .6
SiO_2		11.15						11.15	11.15 ±.1
Cl			3.64			.16		3.8	3.8 ±2.1
NO_3			.07	3.29				3.36	3.36 ±.1
SO_4			.46		1.18			1.64	1.64 ±.1
Pb		.005				.61		.61	.61 ±.1
Zn		.002				.003	.072	.077	.077±.01
Subtotal	16.33	12.53	4.17	3.29	1.18	1.38	4.26	43.14	43.14±3.1
Other	-	10.75	2.45	?	?	.14	.54	13.88	21.1
TOTAL	16.33	23.28	6.62	3.29	1.18	1.52	4.80	57.0	67.0 ± 6
error	±.4	±2.4	±3.9	±.1	±.25	±.32	±1.15	±8.5	
Percent** Contrib.	24.4	34.7	9.9	4.9	1.8	2.3	7.2	85.2	100
error (%)	±.6	±3.6	±5.8	±.1	±.4	±.5	±1.7	±12.7	

* by difference, so that total of organics row will be equal to DATA value.
** percentage which each source column contributes to measured (corrected) DATA TOTAL.

the sources which cause TSP excesses in the Bay Area. The project would be somewhat expensive, but the cost is moderate compared to the control measures now contemplated; especially if the lack of data results in poor choices. For the present, however, reliance must be on the data now available, with some professional judgment and cost considerations, for alternative control measures.

Emission Projections

Table 7 shows that baseline stationary source emissions are not expected to change very much from 1975 to 1985. Slight increases are expected in most categories because of expanding population and economic activity. A notable increase, about 10 tons/day, is foreseen from combustion of fuels at power plants, with a transition from gas to oil and possibly coal. AQMP baseline projections, including stationary and mobile sources, are shown in Table 9 for 1975, 1985 and 2000.

EPA guidelines (see Reference 17) suggest a new emission factor for dust from paved roadways, that is fugitive dust resuspended in the air as a result of vehicle passage. The factor of .012 lb per vehicle mile, if applied to Bay Area total VMT, produces emission rates that overwhelm the entire existing particulate inventory. The results are shown in Table 10. The traditional inventory (of all stationary and mobile sources) for 1975 showed 169 tons/day, supposedly including vehicle exhaust and tire dust. The fugitive dust from paved roads would provide an addition of 411 tons/day for a new total of 580 tons/day. Roadway dust, said to be 90 wt. % below 30 μ (see Reference 17), should thus make up some 70% of the average ambient TSP in 1975 -- even more in future years. The Bay Area monitors are all in urban areas and often traffic influenced, yet total soil-like particles have been found to be below 35% of the TSP filter catch. This 35% includes soil-like particles from all sources, including industry, construction, agriculture and nonurban background. It is larger than the soil dust fractions reported in other urban areas (see Reference 20).

Clearly, the roadway dust emission rate should depend on season, vehicle speed, vehicle size, and state of the roadway. The composite factor now proposed seems much too high. If other fugitive dust estimates, from unpaved roads, agriculture, construction, demolition, storage, etc. were added to the inventory, the soil-like component would be predicted well above 70%. The TSP composition data available do not support this hypothesis.

The emission rate could be very large if most of the mass were lost by fallout before the material reaches the monitor. The fugitive dust document, however, suggests that most emissions are small particles that would remain suspended for a long time. These estimates are shown in Table 11. Particle sizes are very small for most categories, and by weight most of the material is >10 μ. The half-lives for settling out of 15 μ particles are fairly long, greater than one hour except for stable con-

Table 9. Particulate Emissions by Major Source Category

(Reference: AQMP/Tech Memo 11)

Source Category	Baseline Emissions (Tons/Day) 1975	1985	2000
Petroleum Refining	2.5	4.4	5.8
Chemical	4.9	5.2	6.1
Other Industrial/Commercial	75.3	80.8	90.5
Combustion of Fuels	16.3	34.5	30.7
Burning of Materials	12.9	13.9	22.5
Off-Highway Mobile Sources	5.2	6.3	7.8
Aircraft	9.0	11.4	19.4
Light-duty Automobiles	27.8	18.8	22.3
Other Motor Vehicles	15.2	16.3	19.8
Total	169	192	225

Table 10. Fugitive Dust from Paved Roads

Emission Factor: .012 lb/mi, EPA-450/2-77-029, pp. 3-8)

Year	Regional VMT* (miles/day)	Vehicle Dust (tons/day)	Traditional Inventory Total Particulate (tons/day)
1965	47,295,853	284	190
1975	68,608,127	411	169
1985	85,910,789	515	192
2000	116,927,835	702	225

*VMT data from AQMP/Tech Memo 12, Appendix A, Table 1.

Table 11. Particle Size Estimates for Various Sources

Reference: EPA-450/2-77-029, Appendix D

Source Type	Weight % of particles less than stated size		
	30 μ	10 μ	5 μ
Point Sources	99	98	
Area Sources	99	98	
Motor Vehicles	93	91	
Aircraft	93	91	
Aggregate Storage	100	100	100
Construction	100	66	
Paved Roads	90		50
Agriculture	80	62	
Feed Lots	60	40	
Off-road Vehicles	60	40	

ditions. With the given 2.4 m/sec wind, the half-life "range" would be 4 kilometers, even under very stable conditions. Thus rapid physical removal does not seem to offer a good explanation for the discrepancy between the large calculated fugitive dust inventory and the smaller observed soil-like particulate catches.

The data sources for the EPA factor of .012 lb/mile do have overlapping ranges, but the two averages differ by an order of magnitude. The overall average is very near the larger value, and it appears, is much too high. This example emphasizes the tremendous uncertainties associated with fugitive dust calculations. Certainly all source inventory calculations are subject to sizeable error brackets, but many categories have benefitted from intensive study and repeated testing through the years. Fugitive dust calculations, by contrast, are still in a rather primitive state. Fugitive and natural emissions should, without a doubt, be included in source inventories for all pollutants. The process may require several iterations, however, to achieve the degree of credibility now accorded to stationary source inventories.

Other possibilities exist, to explain the observed discrepancy between inventory particulate catch. The traditional source inventory could be much too low, by a factor of about 5. Or the particle size distribution of local soils could be very different from the test soils. However, it is unlikely that the BAAQMD source inventory could be so far off, especially on an annual average basis. It is prepared with careful methodology and documentation. As to the soil particle size, a local soils expert (see Reference 21) found that Bay Area soil samples have substantial silt (2-50 μ) and clay (0-2 μ) fractions, similar to the EPA road dust. Considering the difficulties of testing, the fugitive dust emission factor still seems to be most subject to error. (A recent communication from Region IX EPA (see Reference 22) suggests that the factor of .012 lb/mile for paved road dust should be used only for non-freeway roads, and should be construed to include exhaust and tire dust particulates.)

EXISTING CONTROL PROGRAMS

Particulate matter, as visible smoke and dust, has probably been the most noticeable form of air pollution throughout history, and was the subject of earliest control efforts. The control of particulate emissions has become a diversified effort, with several agencies holding regulatory power over Bay Area sources.

Stationary Sources

The Bay Area Air Pollution Control District -- now the Bay Area Air Quality Management District -- was established in 1955 to develop effective programs for the reduction of air contaminants within the district. Previously, only local ordinances were used to control air pollution. The district's enabling legislation includes the first specific source

controls, the regulation of open burning. It also prohibits the discharge of air contaminants which cause a public nuisance (public nuisance is demonstrated by a certain number of complaints). To date (October 1978) the district has enacted 10 regulations and four of these affect particulate matter from stationary sources. These are summarized in Table 12. Regulations 7 and 8 are based directly on EPA rules for new source performance standards and hazardous pollutants. The district new source review rules (§1308 and §1309 of Regulation 2) were adopted by the California Air Resources Board (ARB) for the BAAPCD.

Only regulations directly related to particulate matter are considered here. There are also numerous limitations on gaseous pollutants (SO_2, organics and NO_x), which may be precursors in the formation of secondary aerosol.

Motor Vehicles

The Air Resources Board is also responsible for setting emission limitations on motor vehicles sold or registered in the State of California. The State has generally been very aggressive in this endeavor, with state standards set earlier and more stringent than federal standards for hydrocarbons, carbon monoxide and, in some cases, NO_x. So far, however, there has been no direct regulation of particulate emissions from vehicles. But the hydrocarbon and CO standards brought catalytic converters, together with unleaded gasoline, with resulting lower particulate emission rates from vehicle exhausts.

Since emission factors are 0.34 gm/mi for leaded fuel light vehicles, and 0.05 gm/mi for unleaded fuel (see Reference 23), this inadvertent control should significantly reduce exhaust emissions by 1985 when more than 96% (see Reference 18) of light duty vehicles will be catalyst models. Again, however, the reduction of 0.29 gm/mi may well be overshadowed by increased fugitive dust emissions of 5 gm/mi (see Reference 17), as Bay Area VMT is projected to increase from 68 million miles/day in 1975 to 86 million miles/day in 1985 (see Reference 18).

Aircraft

EPA promulgated in 1976 a set of emission standards for various types of aircraft engines. These standards were to be applicable to new engines beginning in 1979, and represented pollutant reductions up to 98% of the existing emission rates for HC, CO and NO_x. None of the new standards apply, however, to particulate emissions.

Other Sources

A state law (Title 17, California Administrative Code, subchapter 6) controls sandblasting techniques, abrasives, and visible emissions. There is a general opacity limit of 20%, but the opacity may be 40% under certain conditions, mainly with use of ARB certified abrasives.

Table 12. Summary of Particulate Regulations for Stationary Sources

Reg.No.	BAAPCD Section	General Description
1	2000	Bans open burning; regulates agricultural burning.
2	3110	Limits smoke/dust opacity to 20% (Ringelmann 1).
2	3131	Limits Sulfuric acid mist concentration to .04 GR/SDCF.
2	4112.2	Limits concentration to .05 GR/SDCF (at 6% O_2) for large incinerators.
2	4111.2) 5111.2) 6111.2)	Prohibit emission of large (individually visible) particles.
2	5112) 6112.1)	Limit stack concentration of PM to 0.15 GR/SDCF at 6% O_2.
2	6112.2	Limit mass emission rate to 40 lb/hr.
2	6112.3	Lower limit on grain loading to be required for control (from 0.1 GR/SCF for small sources to 0.02 GR/SCF for large).
2	12110	Prohibits lead emissions which would produce >1 $\mu g/m^3$ ground level concentration by modeling (24 hr average).
2	12111.1	Prohibit lead emission which would cause ground level concentration >1 $\mu g/m^3$ over background by monitoring (30 day average).
2	1308	Require BACT* on new or modified sources emitting >15 lb/hr.
2	1309	Require tradeoffs for new or modified sources emitting >25 lb/hr.

Table 12. Summary of Particulate Regulations for Stationary Sources

(Continued)

Reg.No.	BAAPCD Section	General Description
7		<u>New source performance standards</u>
	2	Limits emission rate for steam generators to 0.1 lb/10^6 BTU.
	3	Limits incinerator emissions to .08 GR/SDCF at 12% O_2.
	4	Limits cement plant emissions to 0.3 lb/ton feed to kiln and limits opacity to 10%, except kiln may be 20%.
	5	Limits opacity of nitric acid plant to 10%.
	6	Limits sulfuric acid plant mist to 0.15 lb/ton product, and opacity to 10%.
	7	Limits asphalt concrete plant to .04 GR/SDCF.
	8	Limits refinery catalytic cracking systems to 1 lb/1000 lbs coke.
	10	Limits secondary lead smelter furnaces to .022 GR/SDCF, and burn off pot furnaces to 10% opacity.
	11	Limits secondary brass and bronze smelter furnaces to .022 GR/SDCF, and blast (cupola) or electric furnaces to 10% opacity.
	12	Limits iron and steel plants to .022 GR/SDCF.
	13	Limits sewage treatment sludge incinerators to 1.3 lb/ton of dry sludge input.
	14	Limits phosphate fertilizer fluoride emissions.
	15	Limits steel plant electric arc furnaces to .0052 GR/SDCF from control devices, also opacity.

Table 12 Summary of Particulate Regulations for Stationary Sources

(Continued)

Reg.No.	BAAPCD Section	General Description
7	16	Limits flouride emissions and opacity from primary aluminum reduction plant operations.
	17	Limits primary copper smelter ore dryers to .022 GR/SDCF.
	18	Limits primary zinc smelter sintering machines to .022 GR/SDCF.
	19	Limits primary lead smelter furnaces and sintering machines to .022 GR/SDCF.
	20	Limits coal preparation plant dryers to .031 GR/SDCF; and pneumatic cleaning equipment to .018 GR/SDCF and 10% opacity.
	21	Limits ferroalloy arc furnaces to 0.99 lb/MW-hr or 0.51 lb/MW-hr (depending on alloy) and 15% opacity. Limits dust-handling equipment to 10% opacity. Prohibits "visible gases" from arc furnaces.
8		<u>Emission standards for hazardous pollutants</u>
	2	Controls visible emission from asbestos manufacture, spraying.
	3	Limits beryllium emission to 10 gm/day or .01 $\mu g/m^3$ 30 day average.
	4	Limits beryllium emissions from rocket motor firing to 10 gm/day.
	5	Limits mercury emission to 3.2 kg/day.

A more general law, employed on some occasions for particulate control is the "public nuisance" section in the State of California Health and Safety Code (Division 20, Chapter 2.5, Article 10, §24360). This prohibits "...discharge from any source whatsoever such quantities of air contaminants or other material which cause injury, detriment, nuisance or annoyance to any considerable number of persons...." This provides very broad coverage of many pollution situations, but is sometimes difficult to enforce. It has been used successfully for dust abatement at construction and demolition sites.

Future Prospects

Traditional baseline emission inventory trends, Table 9, do not show great promise for improved air quality for TSP. The inventory increases slowly, about 1.5% per year, through 1985 and 2000. A rollback (roll-forward?) interpretation would predict a proportional deterioration in air quality, such that each station mean would increase over the years, with possibly more excesses of the standards.

Section - C

ALTERNATIVE CONTROL MEASURES

The Livermore exceedances of the primary AGM in 1975 and 1976 have been attributed to three unusual factors: local construction, drought conditions, and extreme restrictive meteorology. A map of the Livermore site is provided in Figure 2, along with a record of construction activities in the immediate area of the station. The 1977 and 1978 monitoring records indicate that the primary standard will not be exceeded in normal years.

For attainment of the secondary national standard, a variety of control measures can be considered to reduce TSP inventories and ambient readings. For stationary sources, there could be more stringent opacity and grain loading limitations. For vehicles, retrofit particulate traps could be required. And for fugitive dust control, road maintenance and soil stabilization could be improved. Also, more effective dust control could be required during construction and demolition projects.

STATIONARY SOURCES

The BAAPCD Engineering Division made a calculation of the particulate emission reductions to be achieved by the most stringent controls (short of shutting down the sources). This was a scenario requiring BACT on all new and existing sources. A list of BACT criteria is included as Appendix B. This control program should achieve a reduction of 45 tons/day by the year 2000. The origins of these reductions are shown in Table 13, by source category.

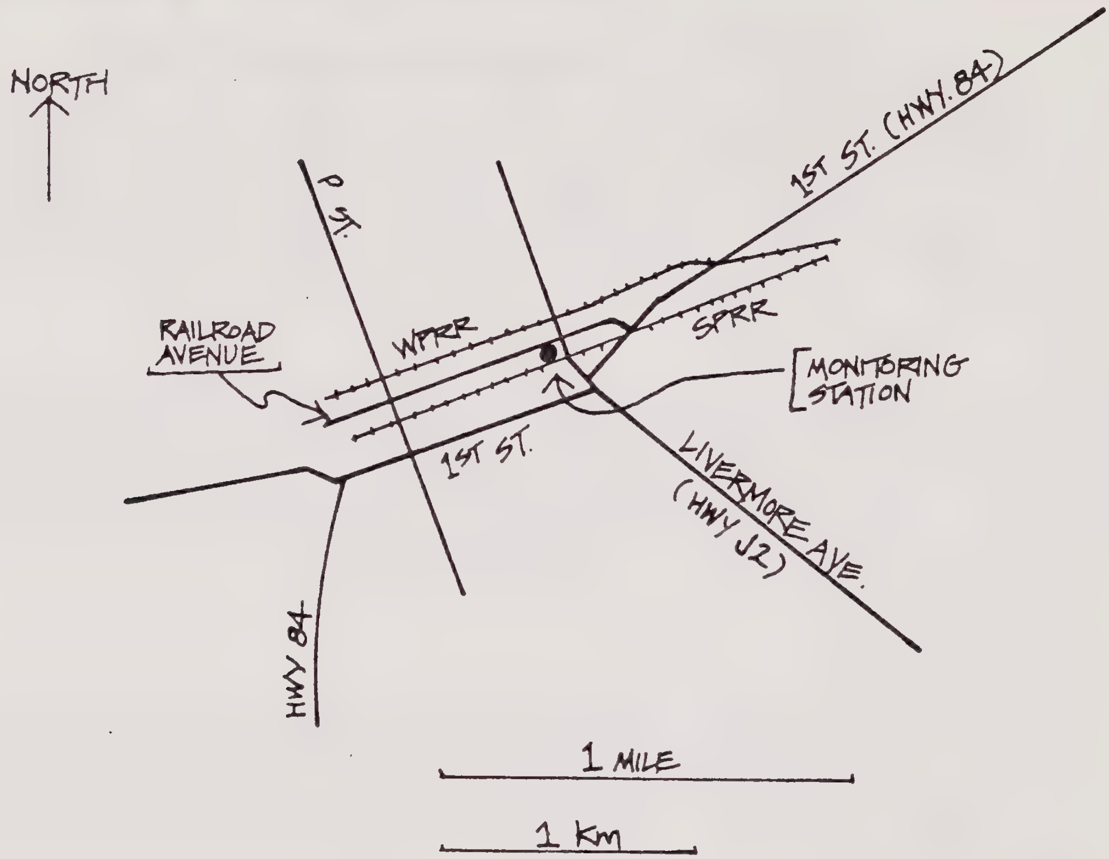
MOBILE SOURCES

Aside from roadbed emissions, which will be considered in Section C (Fugitive Dust), there are only two obvious control measures for motor vehicle particulate emissions. Exhaust emissions could be controlled by fuel specification or by particulate traps in the exhaust system.

For fuel choice, unleaded gasoline should provide lowest particulate emissions, about .05 gm/mi (see Reference 23) with or without a catalytic converter. Leaded gasoline is expected to produce .34 gm/mi (see Reference 23) and diesel fuel engines about .7 gm/mi (see Reference 23), all data quoted for light vehicles. Diesel particulate emissions may be much more pernicious from the standpoint of visibility and catalytic potential. The soot from diesel exhaust appears to behave like activated carbon in providing adsorption sites and catalytic function for formation of secondary particulates in the atmosphere. Thus increased use of diesel-powered vehicles could increase sulfate and nitrate levels in ambient air. Sulfates are considered to be hazardous even at very low concentrations; the California standard (24-hr average) is 25 $\mu g/m^3$ or .0064 ppm. Thus the use of unleaded gasoline would be favored to reduce particulate emission from

FIGURE 2

LIVERMORE MONITORING SITE



CONSTRUCTION PROJECTS IN THE VICINITY OF THE STATION

NO	DATES	DESCRIPTION
1	?	RAILROAD RELOCATION - MOVE SP TRACKS FROM SP RIGHT-OF-WAY TO WP ROADBED.
2.	6/74 - 3/76	LIVERMORE AVENUE UNDERPASS. HIGHWAY GOING UNDER RAILROAD.
3.	6/74 - 2/76	P STREET UNDERPASS, ROAD UNDER RR
4.	74 - 75	RELOCATION OF HIGHWAY 84, EARTH MOVING ALONG SP RIGHT OF WAY.

Table 13. BACT Reductions (Particulate) for 1985 and 2000

No.**	Category	Baseline Inventory Tons/Day 1975	1985	2000	Reductions Tons/day 1985	2000
	PETROLEUM REFINING					
1	Refining Processes	1.41	2.66	3.50	1.40	1.00
2	Other Processes	.80	1.47	1.93	.40	.60
3	Upsets, Breakdowns, Flares	.30	.25	.33	.15	.13
	CHEMICAL					
6	Sulfur	.28	.22	.30	.12	.20
7	Sulfuric Acid	.06	.09	.12	--	--
9	Other Chemical	4.53	5.16	6.10	2.60	3.10
	OTHER INDUSTRIAL/COMMERCIAL					
10	Pulp and Paper	.82	.95	1.12	.45	.60
11	Metallurgical	2.92	3.38	3.99	1.70	2.00
12	Asphaltic Concrete	.79	.73	.86	.60	.10
13	Concrete Batching	1.11	1.27	1.50	1.20	1.30
14	Glass Mfg.	1.63	1.86	2.19	1.00	1.10
15	Stone, Sand, Gravel	15.16	17.30	20.40	11.30	12.40
16	Sandblasting	5.93	6.88	8.15	3.10	4.00
17	Other Mineral	3.74	4.26	5.03	2.10	4.00
18	Farming	10.53	10.30	10.20	--	--
19	Food/Agric. Processing	5.88	6.70	7.92	3.40	3.90
20	Paint Spray Mist	5.74	6.64	7.85	4.00	4.80
21	Wood Products Mfg.	4.69	5.34	6.31	2.60	3.20
22	Other Industrial/Comm	16.35	18.60	22.00	9.30	11.00
	COMBUSTION OF FUELS					
42	Domestic	4.38	4.97	5.90		
43	Comm./Institutional-Gas	1.27	1.73	3.18		
44	-Oil	--	--	--		
45	Oil Ref.Ext.Comb.-Natural Gas	1.42	1.71	2.11		
46	-Ref.Make Gas	1.36	1.90	2.51		
47	-Fuel Oil	.89	4.29	6.59		
48	-Coke	--	--	--		
49	Power Plants-Gas Boilers	1.86	--	--		
50	-Oil	2.77	14.50	3.09		
51	-Coal	--	1.08	.77		
52	-Gas Turbines	--	--	--		
53	-Oil	--	1.44	1.44		
54-66	Other Combustion	2.40	4.45	7.00		
	BURNING OF MATERIALS					
67	Residential Incineration	1.06	1.21	1.43		
68	Comm./Inst. Incin.	.58	.66	.78		
69	Industiral Incin.	.08	.09	.11		
70	Agric. Debris Burning	1.14	1.14	1.14		
71	Range/Forest Burning	.37	.37	.37		
72	Accidental Wild Fires	.28	.27	27		
73	Accidental Structural Fires	9.37	10.70	12.50		
	TOTALS - STATIONARY SOURCES				45.40	53.50

vehicles and other small gasoline engines, such as lawn mowers, generators, chain saws, etc.

Table 14 shows the maximum incremental particulate reduction achievable by use of unleaded gasoline in some non-catalyst vehicles for 1985 and 2000. Note that the baseline inventory already assumes that 96% of light vehicles will be catalyst equipped, and thus already using unleaded gasoline by 1985. Thus, substantial reductions in exhaust emissions have already been considered (see Table 9 "Light Duty Automobiles"). Also shown in Table 14 are the maximum possible reductions achievable with retrofit particulate traps, with a performance standard of 57% reduction (see Reference 24) from conventional muffler emissions. The columns marked "Both" represent maximum reduction attainable, with both measures implemented.

If particulate traps can be used with existing diesel engines, substantial reductions in particulate emissions can be attained, from trucks buses, tractors, construction equipment, ships and locomotives. Total particulate emissions from these sources was 7.64 tons/day in 1975, mostly from trucks and construction equipment. A reduction of 4.35 tons/day would be achieved with particulate traps of 57% efficiency.

AEROSOL PRECURSORS

Since sulfates make up about 5% of the Livermore particulate catch (see Table 8) and nitrates about 2%, these constituents do not show great potential for reductions. The soot and organic component of about 24 weight per cent is somewhat more promising, however. With the soot component expected to be about half of the 24%, the other 12% is probably secondary organic aerosol, which will decrease with the hydrocarbon/oxidant control measures suggested in the AQMP. A total reduction of 43% in hydrocarbons is required by 1985 in order to meet the Federal oxidant standard of .08 ppm by 1985. This represents a total reduction of about 350 tons/day from all sources (see Reference 4), and assuming organic aerosol formation is proportional to ozone production, a 55% reduction in both pollutants is expected. Livermore ambient AGM would decrease by about 7% or 5 $\mu g/m^3$.

For SO_2 and NO_x, application of BACT on certain stationary sources would produce the reductions shown in Table 15. SO_2 reductions on the order of 50% of the total inventory could be achieved through use of BACT on new and existing stationary sources. NO_x reductions would be only about 10%. If secondary sulfate and nitrate are reduced in proportion to precursor emissions, Livermore ambient AGM would decrease by about 3% or 2 $\mu g/m^3$.

Mobile sources collectively also produce large amounts of organics and NO_x, with some SO_2. Vehicle emissions are controlled by State and Federal regulations, and expected reductions in vehicle emissions may decrease secondary aerosols also. Motor vehicle hydrocarbons will decrease by 55% (259 tons/day) from 1975 to 1985. This reduction has already been considered in the 350 tons/day mentioned above. Oxides of nitrogen from

Table 14 Particulate Reduction from Use of Unleaded Gasoline and Retrofit Particulate Traps

Source Category No.	Description	Reduction (ton/day) Unleaded Gas. 1985	Unleaded Gas. 2000	Part. Traps 1985	Part. Traps 2000	Both* 1985	Both* 2000
74	Ag tractors	.12	.12	.08	.08	.13	.13
76	Constr. Equip.	.23	.31	.15	.21	.25	.35
87	Lawn mowers	.14	.15	--	--	--	--
88	Misc. engines	.27	.32	--	--	--	--
94	Cars & lt. trucks	.53	.72	3.28	4.46	3.50	4.77
98	Hvy. gasol. trucks	1.35	1.84	1.81	2.46	2.39	3.25
106	Motorcycles-2 str.	--	--	.15	.20	.15	.20
107	Motorcycles-4 str.	.03	.04	.03	.05	.05	.06

*Note that emission reductions are not additive.

Assumptions

Particulate traps can reduce particulate emissions by 57%, whether unleaded or leaded gasoline.

Cat. 74 All gasoline tractors could use unleaded gasoline with 85% reduction in particulate emissions from leaded gas value (N.B. tractor use outside urban areas has little impact or urban TSP).

76 85% reduction achievable, as with light duty vehicles.

87 85% reduction with unleaded. Lawn mowers not suitable for retrofit particulate traps.

88 85% reduction with unleaded. Not suitable for part. traps.

89-93 (Aircraft) Only small and/or old planes use gasoline. Those require high octane aviation gas. Unleaded could not be used.

Assumptions (Continued)

Cat. 94 Assume 96% of light vehicles will require unleaded by 1985; resulting emissions reductions already figured in baseline inventories for 1985 and 2000. Figures in unleaded column represent incremental reduction if half of remaining 4% switch to unleaded.

98 Half of trucks could switch to unleaded. 42% category reduction.

106 Two-stroke emissions reduced 57% by particulate trap, unaffected by unleaded fuel.

107 Assume half of four-stroke motorcycles could use lower octane unleaded gas. 42% category reduction.

TABLE 15. SO_2 and NO_x Inventories, Baseline and BACT Stationary Source Reductions for 1985 & 2000

A. Sulfur Dioxide SO_2 (tons/day)

Category	Baseline Values* 1975	1985	2000	BACT Reductions** 1985	2000
Petroleum Refining	39.0	67.5	88.9	32.0	42.5
Chemical	84.6	89.1	119.8	84.9	112.3
Other Indus./Commercial	5.9	6.5	7.4	.1	.1
Combustion of Fuels	43.7	213.9	129.9	93.5	56.5
All other sources	45.8	58.0	68.0	--	--
Total - All Sources	219.0	435.0	414.0	211.0	211.0
% Reduction	--	--	--	48	51

B. Oxides of Nitrogen as NO_2 (tons/day)

Category	Baseline Values* 1975	1985	2000	BACT Reductions** 1985	2000
Petroleum Refining	5.9	15.2	20.0	2.8	3.7
Chemical	3.1	2.9	3.9	1.3	1.6
Other Indus./Commercial	2.5	2.7	3.1	.4	.4
Combustion of Fuels	196.0	321.1	279.8	72.4	67.9
All other sources	523.5	350.0	414.0	--	--
Total - All Sources	731.0	692.0	721.0	76.9	73.6
% Reduction	--	--	--	11	10

*Reference AQMP/Tech Memo 11, pages 4-6.
**Calculated by BAAPCD Engineering Division, August 1977.

motor vehicles will be reduced by 36% (144 tons/day) by 1985. The resulting ambient TSP reduction would be less than 1 $\mu g/m^3$. Both pollutants will increase again with increased VMT for 2000, but will still be below 1975 levels (see Reference 18). The year 2000 calculations suppose enactment of mobile source controls to achieve emissions about 50% below 1977 prescribed levels.

SO_2 emissions from mobile sources will not be reduced unless the sulfur content of gasoline is regulated. This does not seem to be an efficient way to reduce either SO_2 or particulate emissions.

Section - D

RECOMMENDED APPROACH TO FUTURE PLANNING

Based on the recent monitoring record, it is expected that the Livermore station AGM will be below 75 $\mu g/m^3$ for the forseeable future. The three conditions which contributed to high TSP in 1975 and 1976 (construction, drought and extreme restrictive meteorology) are not expected to recur, especially simultaneously. The general composition of the Livermore TSP is known, with 35% soil-like particles as the largest fraction and 24% soot/organics as the second largest. Since neither of these is amenable to modeling at this time, we rely on the developing monitoring record to demonstrate attainment by 1978. The 1977 AGM was 68 by BAAQMD calculation and the 1978 AGM is 63 through July 1978.

The soil particle fraction is not amenable to modeling because the source strengths are not known to the accuracy required here. The soot organic fraction cannot presently be modeled because soot source strengths are not known and no reaction chemistry is available to calculate secondary organic aerosol, whether on a prototype day or annual average basis.

Substantial reductions in the hydrocarbon inventory are expected as the oxidant plan is implemented, and the construction near the Livermore station (Figure 2) has been completed. Thus both fugitive dust and organic components should be substantially reduced, though the reductions may not be quantified except through the monitoring record. After two clean years, 1977 and 1978 Alameda County may be redesignated by the ARB or EPA as an attainment area with respect to the national primary particulate standards.

The attainment of secondary standards in four counties presents a more difficult problem, where the solution will depend on control of fugitive dust. With winter rural inland background values of about 30 $\mu g/m^3$ with excursions to 100 $\mu g/m^3$ (see Reference 25), it is clear that the estimation and control of fugitive dust will be a demanding and critical task. Preliminary calculations with EPA's emission factor for reintrainment on paved roads show that this would be a critical area for control. Koch (Reference 26), by contrast, found paved roads a <u>negligible</u> source of fugitive dust in the Baltimore area, and proposed emission factors 1/10 or 1/100 of the EPA value. It is clear that a useful calculation of fugitive emissions must depend on careful analysis of the existing data, and possibly the publication of new research. Even with agreement on emission factors, the fugitive emissions calculations will require collection and analysis of new kinds of data in the Bay Area: crop acreage, unpaved roads and areas, soil moisture, soil particle sizing, precip./evaporation indices, etc. This exercise may require several person-years of work and up to one calendar year to accomplish.

The following tasks are identified and recommended for completion as part of the continuing planning process for air quality:

- Evaluate potential effectiveness of stricter enforcement of existing regulations to control fugitive dust from human activities; opacity limits and public nuisance laws could be invoked for dust control at construction and demolition (or any other) sites.

- Allow fugitive dust reductions for trade-offs in new source review requirements.

- Request State and/or Federal funding for source identification program proposed in AQMP/Tech Memo 24 for size segregated sampling and elemental/microscopic analysis of particulate samples.

- Collect data and prepare a fugitive dust emission inventory for the Bay Area on a county-by-county basis. Model individual stations in non-attainment areas.

- Monitor change in national policy from a total suspended particulate standard to a fine particle standard -- inhalable or respirable fraction.

- Evaluate the potential effectiveness of particulate control alternatives, including Best Available Control Technology for particulate matter emission control on new and existing sources, particulate traps for gasoline and diesel engine emissions control

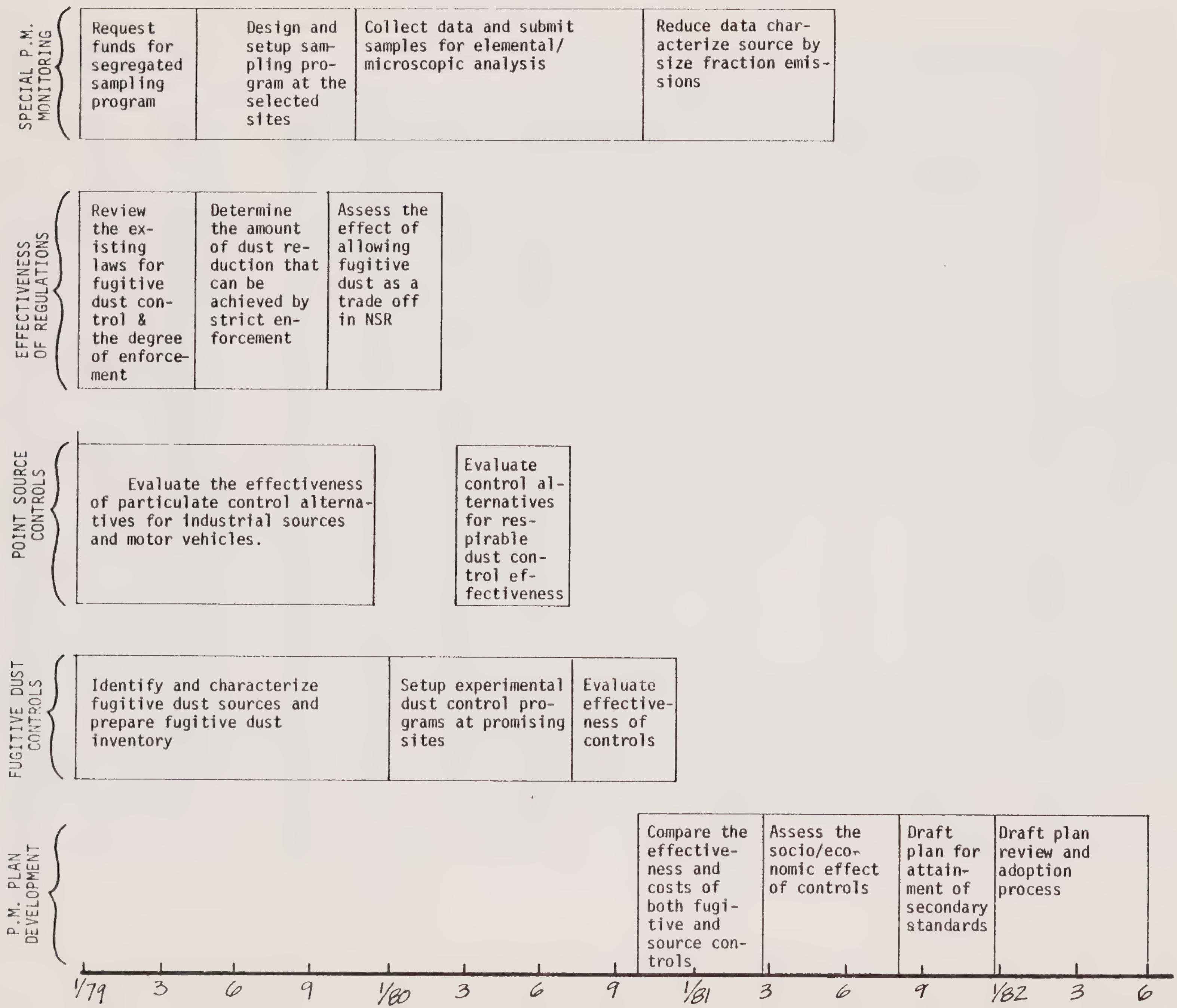
- Design and set up experimental fugitive dust control programs near monitors if the local inventory analysis predicts benefits.

- Evaluate the experimental programs for air quality benefits and implementation costs.

- Formulate plans for attainment of secondary (and State) standards based on results above, and assess the social, economic and other environmental effects of any additional control programs recommended.

A tentative schedule for completion of these tasks is illustrated in Figure 3, assuming appropriate funding (e.g., nonattainment area planning funds) is available by January 1979.

Figure -3 TENTATIVE SCHEDULE FOR WORK ON PARTICULATE MATTER PLAN UPDATE



Section - E

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APPENDIX A. 24-hr Average TSP Values >150 μg/m³ by Station and Date - 1975

1975	SF	PO	SR	RI	PT	CC	FR	LI	SJ	GI	SU	SA	RC	BU	ST	NP	VA	PA	MB	WSJ	SJ AIRPT	NORTH SJ AIRPT	NASN STATIONS BE	OA	SF	SJ
	DISTRICT STATIONS																									
Jan 12																			181†		155					
15										152											187					
18										172											201					177
21																157						204				
24					180			155		175											173	166				
Feb																										
Mar 25																			167							
28																			248							
Apr																					↑	↑				
May 18				161													151									
Jun																										
Jul 29																			155							
Aug 22								180																		
28								174																		
Sep 24								178				- not open -						- not open -			no data	no data	none >150	none	none	
Oct 6	275*																									
Nov 2																	201									
Dec 2							169	166																		
5								160											188							
8							173																			163
14								152																		
17								166											171							
29								167													↓	↓				
Primary	- none -																									
Secondary							x	x		x							x		x		x	x				x
AGM (BAAPCD)**	49		30	35	44	31	49	69	58	51	39		42	33	44	54	51									
AGM (ARB)***	49	54	41	45	53	34	55	80	65	56	44		46	35	38	55	59									
AGM (NASN)																							<39	<48	<53	<72
Primary AGM								x																		

†Monthly summary note "excavation in adjacent area."
*"New roof being installed on adjacent building."

**BAAPCD AGM values based on approx. 120 samples, glass fiber and cellulose filters.
***ARB calculation of AGM, approx. 60 samples, glass fiber filters.

DISTRICT STATIONS

1976	SF	PO	SR	RI	PT	CC	FR	LI	SJ	GI	SU	RC	BU	ST	NP	VA	PA	MB	WSJ	OA
Jan 16		151																		
19		152																		
24								246	159											
27								198												
30	166	170				171		601*										288		
Feb																		no data		
Mar																				
Apr																				
May																				
Jun 22									152											
28								155												
Jul 22					158															
Aug																				
Sep 2								170												
8																		190		
Oct 5												173					- not open -			
20							153													
Nov 1		155			204			166								176				
7		159						152												
25								156												
Dec 1					168													Nov/Dec - no data		
4							156												162	
7		164			158		152		175											
13																			167	
16							183	180				207								
19							163								167					
25			170	163	175	265	200	171	155		166	244								
28						156	162	160				182			173					
Primary	- none -																			
Secondary		x			x	x	x	x	x			x			x			x	x	
AGM(BAAPCD)**	55	62	36	48	61	51	62	85	71	62	50	59	49	66	65	52				
AGM(ARB)***	53	63	40	58	66	52	61	87	75	62	50	57	41	45	61	52				
Primary								x												

NASN STATIONS

1976	BE	OA	SF	SJ
Jan	none			
31				155
Feb				
Mar				
Apr				
May				
Jun				
Jul				
Aug				
Sep				
Oct				
Nov 2		167	163	213
8		166	211	214
Dec 2				211
14				239
20				215
26			168	243
Secondary		x	x	x
AGM(NASN)	41	55	47	71

*Data sheet note "construction in adjacent area."
**District calculation of AGM, approx. 120 samples on cellulose and glass fiber.
***ARB calculation of AGM, approx. 60 samples, glass fiber only.

1977	SF	PO	SR	RI	PT	CC	FR	LI	SJ	GI	SU	RC	BU	ST	NP	VA	PA	MB	WSJ	OA	BE	OA	SF	SJ
	DISTRICT STATIONS																				NASN STATIONS			
Jan 9												174												
31																								153
Feb 14																		161						
Mar																	not open							
Apr 12																		161						
May																								
Jun 23																	256							
26																	206							
29																	188							
Jul 29								179									*				- none -	- none -	- none -	
Aug 1																	257							
22																	193							
25																	174							
28																	561							
Sep 6																	169							
18																	242							
21																	206							
30														185			227							
Oct 9																	156	156						
12										161							237							
15																	285							
24																	501							
27																	166							
Nov 2																	323							
8																	286	174						
14																	279							
17		188															227							
26																	238							
29																	464							
Dec 20**	1192	1173	1071	1817	2745	688	870	1130	810	1003	425	699	968		2552	3271		1295	742	1332				
28																	163							
AGM (BAAPCD)	41	56	34	51	54	49	60	68	64	62	45	52	34	35	53	42								
AGM (ARB)	- not available -																							
AGM (NASN)																					40	49	44	72

*No data available.
**Bakersfield dust storm.

	DISTRICT STATIONS																				NASN STATIONS			
1978	SF	PO	SR	RI	PT	CC	FR	LI	SJ	GI	SA	RC	BU	ST	NP	VA	PA	MB	WSJ	OA	BE	OA	SF	SJ
Jan 1																		330			no reading >150 during 1st or 2nd quarters	no reading >150 first quarter		no reading >150 during 1st or 2nd quarters
Feb 18																	176							
Mar 23																	235							
26																	235							
Apr 1																	266							
4																	252							
7																	378							
13																	247							
16																	177							
May 1																	356							
7													175											
10																	266							
13																	195							
19																	192							
22																	298							
Jun 3																	208							
6																	208							
12																	166							
15																	362							
18																	205							
24																	259							
30																	185							
Jul 6								190																
9																	188							
18																	265							
21																	170							
30																	272							
Aug 5																	216							
14																	326							
17																	241							
26																	255							
29																	206							
Primary																	x							
AGM (BAAPCD)*	38	47	33	47	54	39	52	63	58	52		45	33	33	48	37								
Primary AGM																	x							

*Through July 1978.

APPENDIX B. Best Available Control Technology for Particulate Matter from Certain Sources

No.	Process	BACT Description	Performance Criteria
1.	Fluid catalytic cracker & coker	3-stage electrostatic precipitator	10 to 15 lb/hr
2.	Boilers and furnaces	A. low sulfur fuel oil B. ammonia injection	0.25% sulfur 50% reduction
3.	Feed mills	A. baghouses B. electrostatic precipitator	99% at 1 μ 86% at 1 μ
4.	Fish meal rendering	A. scrubber with incinerator B. chlorine injection and chemical scrubber	98-99% 95-99%
5.	Concrete Batch	baghouse	99% at 1 μ
6.	Rock plants	water spray system with wet agent	99%
7.	Hot asphalt, Perlite	A. baghouse B. venturi scrubber with baghouse	99% at 1 μ
8.	Abrasive	A. baghouse B. venturi scrubber C. shrouding	99% at 1 μ 97% at 1 μ
9.	Abrasive blasting, unconfined	A. water injection B. hydroblasting C. certified (dry) abrasives	70-80% 100%
10.	Rock drills	water injection	70-80%

No.	Process	BACT Description	Performance Criteria
11.	Burn out ovens brake shoe debonders	starved air combustion plus afterburner	90%
12.	Incineration of waste	A. starved air combustion plus afterburner	90%
		B. baghouse	99% at 1 μ
13.	Concrete, flour and grain storage silos	baghouse	99% at 1 μ
14.	Metal, melting wire recovery	A. baghouse B. venturi scrubber	99% at 1 μ
15.	Tire buffers	water injection	70-80%
16.	Architectural coatings	low solvent coatings	70=80%

ADDENDUM TO EMP VOLUME III - SUMMARY OF COMMENTS AND RESPONSES

Carbon Monoxide/TSP Control Programs

Comment	Response
San Francisco Bay Chapter, Sierra Club: We endorse the general proposals in the transportation controls, but more transit riders could be carried without increasing labor costs by hiring more bus drivers. MTC could easily provide for local matching funds for high-capacity bus grants by eliminating bridge toll discounts for automobile commuters. No mention is made of responsibility of local governments to aid transit by traffic signal priority for transit vehicles.	We agree with your assessment of the potential and desire to use articulated and other high-capacity buses wherever possible. Currently, a number of transit programs in the Bay Area are using such vehicles (e.g. A-C Transit) and we would expect their use to increase as their effectiveness and utility are demonstrated and funds become available for their acquisition. Traffic flow improvements in localized CO hot spots will be examined in continuing planning process.
Charles Kinney, Building Industry Association CO/TSP program should require that Federal standards be re-examined. Only control measures that should be included are those that are reasonable. Inventories for CO, TSP, natural dust and fugitive dust are critical. Inventories are not as current as they should be, so it is premature to require strict control measures.	As we have already noted on numerous occasions, the Clean Air Act of 1977 already requires a periodic review of all air quality standards, including those for CO and TSP. Further, any measures recommended in the plan have been assessed by staff and are considered both reasonable and cost-effective. Refinements in the emission inventories are a key task in the air quality continuing planning process.
Angelo Siracusa, Bay Area Council By and large, CO and TSP plans are adequate. BAC supported proposed resolution on the 1979 Bay Area Air Quality Plan.	None required.
League of Women Voters of the Bay Area: "(we) support measures to reduce vehicular pollution, including inspection and controls.... The League...is asking ABAG to take a leadership role in getting enabling legislation and grassroots support for this program among community leaders and locally elected officials.	We appreciate the support of the League for programs recommended in the air quality plan. ABAG intends to work diligently in 1979 with key local officials, citizens groups and State legislators to secure legislation permitting and establishing a mandatory vehicle inspection and maintenance program for the Bay Area.

Comment	Response
Bay Area Lung Associations: "We support in general the actions listed for the Carbon Monoxide Plan...Every effort should be made to assist local municipalities in solving circulation problems on the roadways which contribute to the carbon monoxide problem...We support the actions listed for...the continuing planning process for total suspended particulates...We ask you to consider the positive benefits of pollution control in terms of improved health, safety, and general quality of life."	We appreciate the support of the Lung Associations and will continue to work for plans which balance protection of public health and welfare with other societal needs.
PG&E "ammonia injection (Thermal de-No_x) is proposed as best available control technology (BACT) for TSP...it is the least efficient and only indirect control method suggested for reducing TSP...we request that ammonia injection be removed from the list of alternative BACT."	Although ammonia injection does reduce TSP levels somewhat, we agree it is not generally viewed as a BACT for TSP. It has been deleted from the Table in the final plan.